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MATHEMATIK

ÜBER EINE ANWENDUNG DER UNGLEICHUNG VON H. BOHR UND J. FAVARD

Von N. ACHYESER und B. LEWITAN

(Vorgelegt von S. N. Bernstein, Mitglied der Akademie, d. 4. II. 1937)

Die in Rede stehende Ungleichung lautet:
Besitzt die periodische (komplexe) Funktion

$$f(x) = \sum_{k=n}^{\infty} (a_k \cos kx + b_k \sin kx) \qquad (n \geqslant 1)$$

eine integrierbare Ableitung $f^{(r)}(x)$ der Ordnung $r \geqslant 1$ und ist

$$|f^{(r)}(x)| \leqslant M,$$

so besteht die Ungleichung

$$|f(x)| \leqslant \frac{4}{\pi} K_r \frac{M}{n_r},$$

wo

$$K_r = 1 - \frac{1}{3^{r+1}} + \frac{1}{5^{r+1}} - \cdots < 1$$

für gerades r und

$$K_r = 1 + \frac{1}{3^{r+1}} + \frac{1}{5^{r+1}} + \cdots \leqslant \frac{\pi^2}{8}$$

fur ungerades r.

Spezialfälle dieses Satzes von J. Favard (1) wurden gegeben von H. Bohr (2) und J. Favard (3) ($r = 1, n \geqslant 1$) und S. Bernstein (4) ($r \geqslant 1, n = 1$).

In diesem Aufsatze wollen wir zeigen, dass aus dem Satze von J. Favard unmittelbar und dabei in vervollständigter Form der Fundamentalsatz von D. Jackson (5) über Annäherung differenzierbarer periodischer Funktionen durch trigonometrische Summen folgt.

Es sei θ irgendeine Zahl aus dem Intervalle $0 < \theta < 1$ und

$$d(t) = \frac{\cos\frac{(1-\theta)t}{\theta} - \cos\frac{t}{\theta}}{\pi t^2},$$

$$\varphi(u) = \begin{cases} 1 & \text{für } 0 \leqslant u \leqslant 1-\theta, \\ \frac{1}{\theta}(1-u) & \text{für } 1-\theta \leqslant u \leqslant 1, \\ 0 & \text{für } u \geqslant 1, \end{cases}$$

$$\varphi(-u) = \varphi(u).$$

Bedeutet $f(x)$ eine integrierbare (komplexe) Funktion mit der Periode 2π und ist

$$f(x) \sim \sum_{k=-\infty}^{\infty} c_k e^{ikx},$$

so ist

$$\int_0^{\infty} \left\{ f\left(x + \frac{t}{\theta n}\right) + f\left(x - \frac{t}{\theta n}\right) \right\} g(t)\, dt = \sum_{|k|<n} \varphi\left(\frac{k}{n}\right) c_k e^{ikx} = \sigma_n \{ f; \theta \}.$$

Falls dabei

$$|f(x)| \leqslant M,$$

so ist

$$|\sigma_n \{ f; \theta \}| \leqslant 2M \int_0^{\infty} |g(t)|\, dt = \frac{4M}{\pi} \int_0^{\infty} \frac{\left|\sin\frac{(2-\theta)t}{2\theta}\right| \cdot \left|\sin\frac{t}{2}\right|}{t^2}\, dt <$$

$$< \left(2 + \frac{2}{\pi} \log\frac{1}{\theta}\right) M. \qquad (1)$$

Satz. Besitzt die periodische Funktion $f(x)$ eine integrierbare Ableitung $f^{(r)}(x)$ $(r \geqslant 0)$ und ist

$$|f^{(r)}(x)| \leqslant M_r,$$

so besteht die Ungleichung

$$|f(x) - \sigma_n \{ f; \theta \}| \leqslant \frac{A + B \log\frac{1}{\theta}}{(1-\theta)^r} \frac{M_r}{n^r}, \qquad (2)$$

wo A, B absolute Konstanten sind, wobei $A < \frac{12}{\pi} K_r \leqslant \frac{3}{2}\pi$, $B < \frac{8}{\pi^2} K_r \leqslant 1$.

Vorbemerkung. Dieser Satz unterscheidet sich von dem Satze von D. Jackson dadurch, dass die hier benutzte trigonometrische Summe $\sigma_n \{ f; \theta \}$ unabhängig von der Zahl der Ableitungen, welche $f(x)$ hat, ist*.

Beweis. Aus der Bedingung des Satzes und (1) folgt, dass

$$|f^{(r)}(x) - \sigma_n \{ f^{(r)}; \theta \}| < M_r + \left(2 + \frac{2}{\pi} \log\frac{1}{\theta}\right) M_r.$$

Da aber

$$f^{(r)}(x) - \sigma_n \{ f^{(r)}; \theta \} \sim \sum_{m+1 \leqslant |k| \leqslant n} \left\{ 1 - \varphi\left(\frac{k}{n}\right) \right\} c_k (ik)^r e^{ikx} + \sum_{|k|>n} c_k (ik)^r e^{ikx},$$

wo $m = [n(1-\theta)]$ ist, so folgt aus der Ungleichung von J. Favard, dass

$$|f(x) - \sigma_n \{ f; \theta \}| < \frac{4}{\pi} K_r \left(3 + \frac{2}{\pi} \log\frac{1}{\theta}\right) \frac{M_r}{(m+1)^r} \leqslant$$

$$\leqslant \frac{4}{\pi} K_r \left(3 + \frac{2}{\pi} \log\frac{1}{\theta}\right) \frac{1}{(1-\theta)^r} \frac{M_r}{n^r}.$$

Das bekannte Verfahren von D. Jackson (7) erlaubt zu zeigen, dass

$$|f(x) - \sigma_n \{ f; \theta \}| \leqslant \frac{A' + B' \log\frac{1}{\theta}}{(1-\theta)^{r+1}} \frac{1}{n^r} \omega_r\left(\frac{\pi}{n}\right),$$

* Wir wollen noch auf die Einfachheit der Konstruktion der Summe $\sigma_n \{ f; \theta \}$, welche nichts anderes als eine leichte Modifikation der Fejérschen Summe $\sigma_n(x) = \sigma_n \{ f; 1 \}$ ist, hinweisen. Vgl. N. Achyeser (6).

falls $f^{(r)}(x)$ den Kontinuitätsmodul $\omega_r(\delta)$ hat A', B' sind absolute Konstanten, und zwar ist $A' \leqslant \left(2 + \frac{1}{\pi}\right) A$, $B' \leqslant \left(2 + \frac{1}{\pi}\right) B$.

Es sei bemerkt, dass unsere Abschätzungen auch dann gültig bleiben, wenn θ von n abhängig ist. Setzt man $\theta = \frac{1}{n}$, so wird

$$\sigma_n\left\{f; \frac{1}{n}\right\} = s_{n-1}(x) = \sum_{|k|<n} c_k e^{ikx}$$

(die Fouriersche Summe der Funktion $f(x)$ der Ordnung $n-1$).

In diesem Falle nehmen die Ungleichungen (2), (3) die Gestalt:

$$\left.\begin{aligned} |f(x) - s_{n-1}(x)| &\leqslant (A + B\log n)\frac{M_r}{(n-1)^r}, \\ |f(x) - s_{n-1}(x)| &\leqslant (A' + B'\log n)\frac{n}{(n-1)^{r+1}}\,\omega_r\left(\frac{\pi}{n}\right) \end{aligned}\right\} \qquad (n>1),$$

an, was im wesentlichen mit bekannten Abschätzungen des Restgliedes der Fourierschen Reihe einer differenzierbaren Funktion übereinstimmt.

Ferner sei noch bemerkt, dass eine ähnliche Modifikation anderer Summationsmethoden Fourierscher Reihen zu denselben Resultaten führt.

Als Beispiel erwähnen wir die Cesàro—M. Rieszsche Methode einer beliebigen Ordnung $p > 0$.

Setzt man hier

$$\varphi(u) = \begin{cases} 1 & \text{für } 0 \leqslant u \leqslant 1-\theta, \\ \frac{1}{\theta^p}(1-u)^p & \text{für } 1-\theta \leqslant u \leqslant 1, \\ 0 & \text{für } u \geqslant 1, \end{cases}$$

$$\varphi(-u) = \varphi(u)$$

und konstruiert man $\sigma_n\{f; \theta\}$ vermittelst einer neuen Funktion $\varphi(u)$, so entstehen die Ungleichungen (2), (3) mit nur von p abhängenden Konstanten A, B, A', B', wobei eine grobe Rechnung zeigt, dass

$$A < 15 + \frac{2\pi(4+\pi)}{p} + 2\sqrt{\pi}\,\frac{\Gamma(p+1)}{\Gamma\left(p+\frac{1}{2}\right)}, \quad B < 1$$

$$A' \leqslant \left(2 + \frac{1}{\pi}\right) A, \quad B' \leqslant \left(2 + \frac{1}{\pi}\right) B.$$

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PHYSICS

THE ABSOLUTE CONCENTRATION OF EXCITED ATOMS IN A LOW-PRESSURE MERCURY DISCHARGE

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(Communicated by S. I. Wawilow, Member of the Academy, 15. I. 1937)

The low-pressure mercury discharge is the type of discharge most thoroughly studied from the point of view of its electrical and gaso-kinetic characteristics. In this discharge, most of the energy is considered to be spent on the excitation of atoms (1). There is, however, no direct literary evidence available as to the concentration of excited atoms in the low-pressure mercury discharge. In his survey (2), Ladenburg refers to Mohler (3), who has calculated by an indirect method the concentration of excited atoms in the mercury discharge from the results of Killian's electrical measurements (4). However, as we shall see below, the results of his calculations give rise to doubt if compared with direct experimental data.

§ 1. The object of this work was to determine by the direct method the concentration of excited atoms in the low-pressure mercury discharge, the atom concentrations being measured at the three most important levels, $6^3P_{0,1,2}$.

From these three levels, 6^3P_0 and 6^3P_2 are known to be meta-stable, while 6^3P_1 is the upper level for resonance line 2537. The concentrations were determined by the absorption method, by measuring the absorption in the discharge of visible triplet lines ending at the above-mentioned levels: 5461(6^3P_2—7^3S_1), 4358 (6^3P_1—7^3S_1), 4047 (6^3P_0—7^3S_1).

Absorption was measured in a mercury discharge tube of special design, as used in probe measurements.

This tube has a liquid cathode, the vapour pressure within the tube being maintained by a water bath, wherein the cathode end of the tube is immersed. The diameter of the tube was 32 mm. Absorption was measured in the positive column of the discharge, at 3 A and at varying vapour pressures (10^{-4}—10^{-3} mm Hg). The choice of discharge conditions under which the optical measurements were made was determined by the fact that Klarfeld had made his careful probe measurements under identical conditions.

Similarly to what was done in investigating the high-pressure discharge(5), the source of light used in our absorption measurements was a tube identical to the one under examination, the conditions being altered simultaneously

in both tubes*. In order to obtain reliable results, the identity of conditions in both tubes must be scrupulously maintained throughout the period of measurement**. The measurements of intensities were made both by the subjective method (a König-Martens spectrophotometer) and by the objective method (a powerful monochromator and selenium-cell). It is a matter for regret that, owing to the low intensity of the discharge radiation, the objective method could not be used at all pressures.

The discrepancies between the objective and the subjective measurements lies well within 5%.

§ 2. Table 1 shows the absorption values for the visible triplet of mercury lines at various vapour pressures.

Table 1

p in mm Hg	5 461	4 358	4 047
$2.5 \cdot 10^{-4}$	0.35	<0.05	0.22
$9.0 \cdot 10^{-4}$	0.70	0.18	0.40
$2.9 \cdot 10^{-3}$	0.77	0.28	0.55
$7 \cdot 5 \cdot 10^{-3}$	0.82?	0.56	0.59

Table 2

5 461	4 358	4 047
100	350	100
100	150	67
100	84	49
100	360	126

Before discussing in detail the data contained in Table 1, we should like to emphasize theconclusion of a purely optical nature that may be drawn from these data. It may be seen that, within the range of pressures investigated by us, line 5461 has the highest absorption: line 4047 comes next, and line 4358 has the lowest absorption. Consequently the reabsorption of line 5461 should also be the greatest, line 4047 coming next and line 4358 showing the least reabsorption. All the experimental evidence so far available for pressures between 10^{-2} and 1000 mm Hg showed the relation between the reabsorption values to be inverse ([7]).

In these conditions the highest reabsorption was possessed by line 4358 and the lowest by line 5461, the intensities in the triplet showing corresponding divergencies from the theoretical values.

In the conditions of our experiments, the divergencies of the intensity relations in the visible triplet should be reversed. Line 5461 should be weakened with respect to lines 4358 and 4047.

The first line of Table 2 shows the results of our measurements of the relations between the intensities for a pressure of 10^{-3} mm Hg. Line 2 shows the theoretical relations, and line 3, the data obtained for a pressure of 200 mm Hg ([8]). (Line 4 contains the data for a pressure of 10^{-3} mm Hg in a tube of 60 mm in diameter and with a 5 A current. We shall revert to these data in § 4.)

Experimental evidence is seen fully to confirm our inferences, the relation between the intensities at 10^{-3} mm Hg differing considerably from the theoretical.

As may be seen from Table 1, an increased pressure results in an increased absorption of the three lines. On the other hand, measurements of the angular distribution of intensities show that the reabsorption of line 5461 decreases at pressures exceeding 10^{-2} mm Hg ([9]). A comparison of these two results would justify the assumption of the existence of a maximum of absorption for line 5461 at pressures approximating 10^{-2} mm Hg.

§ 3. In order to pass from the absorption value to the concentration of the absorbing atoms, we must know the absolute value of the probability of absorption (the Einstein B coefficient) for the atomic state concerned. Besides, the shape of the lines is also ofagreat importance. In mercury the absolute values of B may so far be determined, in addition to the resonance lines, only for the visible triplet under discussion.

In doing this, we started from the value of the lifetime of state 7^3S_1 determined by Mitchell and Murphy ([10]) by the polarization method, and used the well-known formula connecting the Einstein coefficients.

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* In obtaining preliminary results the writers used the autocollimation method briefly described in one of their previous papers ([6]).

** Neither tube was disconnected from the vacuum apparatus.

In our case, the shape of the lines of the source and of those of the absorbing layer was identical. Since we worked in a low pressure range, we were justified in considering the shape of the lines to be a purely Dopplerian one.

In a high-pressure discharge the shape of the lines is a very complex one. This made it impossible to calculate the absolute concentrations from the absorption measurements previously carried out at our laboratory for the high-pressure discharge ([5]).

The coefficient of absorption in the centre of the line can then be expressed as follows:

$$k_0 = 1 \cdot 10^{-12} N$$

N being the concentration of absorbing atoms. (The coefficient of N has been calculated taking into account the h. f. s. of the lines from the absolute value of B which is the same for all the three lines of the triplet, owing to the fact that the latter obeys the rule of sums.)

The relation between the absorption value and the value of k_0 for the case of the Dopplerian shape of the lines is known [cf. e. g. the table on p. 323 of Mitchell and Zemansky's book ([11])].

Table 3

p in mm Hg	$N \cdot 10^{-11}$					
	6^3P_2		6^3P_1		6^3P_0	
$2.5 \cdot 10^{-4}$	2.1	45	<0.3	33	1.2	12
$9.0 \cdot 10^{-4}$	7.2	103	0.96	76	2.52	29
$2.9 \cdot 10^{-3}$	10.8	143	1.62	113	4.32	45
$7.5 \cdot 10^{-3}$	13.8?	143	4.50	123	4.92	54

Columns 2, 4 and 6 of Table 3 show the atom concentrations at levels $6^3P_{0,1,2}$ calculated in this manner. It should be mentioned that, when the absorption values rise above 80%, the determination of the concentrations becomes unreliable. Slight errors in absorption value involve great errors in the estimate of concentration. This reduces the applicability of the absorption method, if the lines of emission and the lines of absorption are identical in shape. Only by varying the shape of the lines is it possible to reduce somewhat the absorption value and to raise the accuracy of the determination of concentration.

§ 4. The values obtained by us for the concentration of excited atoms show that the conditions of discharge under investigation are far removed from the conditions of thermal equilibrium. Columns 3, 5 and 7 of table 3 show the concentration values corresponding to the Bolzmann distribution and calculated from the electron temperatures as determined by Klarfeld. The concentrations measured by the writers are thus seen to differ from the calculated values more than by 1 order.

The indirect method of calculating concentrations as used by Mohler is of such a nature as to be applicable only to conditions approaching thermal equilibrium (as, for instance, in a cesium discharge) and is obviously inaccurate in conditions such as ours. Killian's experiments were made with a still lower current density than ours, i. e. the conditions were still farther removed from thermal equilibrium and Mohler's figures were found to be exaggerated.

Moreover, Mohler's calculations were based on the assumption that at level 6^3P_2 the concentration is negligible as compared with concentrations at levels 6^3P_1 and 6^3P_0.

The results of absorption measurements may be seen to be at variance with this assumption. It is true that, inasmuch as the absorption measurements were made under somewhat different conditions than Killian's experiments (a smaller diameter, a greater current density), the transfer of the results obtained in one set of conditions to another set of conditions might appear unjustified. In order to remove this objection, we measured the relation between the intensities in the visible triplet near the discharge tube under conditions identical to those used in Killian's experiments. The measurement results (cf. line 4, Table 2) show the distribution of the atoms among the levels $6^3P_{0,1,2}$ to be of the same kind as in our case.

If concentration at level 6^3P_2 is not neglected, this would result in a more than twofold increase of the values, calculated by Mohler (50% of all the atoms being excited!)

§ 5. The distribution of the atoms among the levels as calculated by the writers is in good agreement with the excitation functions calculated for these levels by Penney ([12]). Penney's calculations show the probabilities of excitation of these levels by slow electrons to be roughly proportional to their static weights, i. e., the greatest probability is possessed by level 6^3P_2.

A calculation taking into account the electron temperature data as well as the form of excitation functions, and based on the assumption of an equal lifetime of both meta-stable levels results in such concentrations at these levels as approximate the experimental ones. This shows that the lifetimes of both levels are not in fact remote from each other.

From the absolute concentration of atoms at level 6^3P_1, we may calculate the intensity of the resonance line, the probability of whose emmission is 10^{+6} ([13]).

For a pressure of $2.9 \cdot 10^{-3}$ mm Hg we obtain $5.6 \cdot 10^6$ erg/sec. From the balance of energy of the discharge it follows that, under these conditions, about $8 \cdot 10^6$ erg/sec is spent on radiation. From a comparison of concentrations at levels 6^3P_1 and $6_3P_{0,2}$, we may estimate the lifetime of meta-stable atoms (taking into account the excitation function of level 6^3P_1).

For a pressure of $2.9 \cdot 10^{-3}$ mm Hg, the lifetime of meta-stable atoms is $7 \cdot 10^{-6}$ sec.

The lifetime of meta-stable atoms in a vessel of the same size as the discharge tube and at the same pressure is of the order of 10^{-5} sec ([14]), the meta-stable atoms being destroyed on the walls.

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PHYSIK

ÜBER EIN AUF DEM PRINZIP DES GASTHERMOMETERS BERUHENDES RADIOMETER VON GERINGER TRÄGHEIT

Von M. VEINGEROV (WEINGEROFF)

(Vorgelegt von S. I. Wawilow, Mitglied der Akademie, d. 19. 1. 1937)

In der vograngehenden Abhandlung* ist die Berechnung der Grenzempfindlichkeit eines auf dem Prinzip des Gasthermometers beruhenden Radiometers durchgeführt worden unter der Voraussetzung, dass alle möglichen Messungsfehler mit Ausnahme der statistischen Schwankungen, beseitigt seien. Bei dieser Berechnung wurde vorausgesetzt, dass das Messinstrument aus einem Gasbehälter besteht, der mit einem für die Strahlung durchsichtigen Fenster versehen ist; im Gas befindet sich eine sehr dünne geschwärzte Platte, auf welche die Strahlung gerichtet ist. Unter Einwirkung der Strahlung wird die Platte erwärmt, und erwärmt ihrerseits das Gas. Die zu messende Ausdehnung des Gases ist proportional der Intensität der auffallenden Strahlung; bei dieser Berechnung sind keine spezielle Voraussetzungen über die Konstruktion des Messinstruments gemacht worden. Die Berechnung hat zum Schluss geführt, dass die durch die Schwankungen bedingte Empfindlichkeitsgrenze des Radiometers die der übrigen Strahlungsmessgeräte um einige Grössenordnungen übersteigt.

Den Zweck dieser Veröffentlichung bildet die Darlegung einiger Betrachtungen über die im Radiometer vorsichgehende Verwandlung der Strahlung in Wärme.

1) Es ist möglich zu berechnen, um wieviel sich der im Gas eingeschlossene Energieinhalt unter der Einwirkung der auf das Radiometer fallenden Strahlung vergrössert, vorausgesetzt, dass sich ein stationärer Prozess eingestellt hat.

Unter der Annahme, dass die Oberfläche der aufnehmenden Platte klein ist, so dass von der Ausstrahlung abgesehen werden kann, was richtig ist, wenn die Oberfläche $\ll 1$ cm^2 ist (für Luft berechnet), und dass wegen der Konvektion** kein Wärmeverlust vorhanden ist, kann berechnet werden, dass der Wärmeinhalt des Gases, dank der auf das Radiometer fallenden Strahlung, sich beim stationären Prozess um den Wert:

* M. Veingerov, (Weingeroff), C. R. Acad. Sci. URSS, III, 119 (1936).

** Die Konvektion kann abgeschwächt werden, indem man die Empfangsfläche mit einer durchsichtigen Flaumschicht umgibt welche die an der Oberfläche entstehenden Gasströme zerstört.

$$\Delta Q = \frac{Jcr^2}{6K}$$

vergrössert, wo J—den auffallenden Lichtstrom in erg/sec., K—die Wärmeleitung des Gases, c—seine Wärmekapazität (bezogen auf 1 cm³), r—den Radius des Behälters, in dem sich das Gas befindet (zur Vereinfachung der Berechnung wird der Behälter als sphärisch angenommen), bedeuten. Die mittlere Temperaturerhöhung des Gases wird dann als

$$\Delta T = \frac{J}{8\pi K r}$$

errechnet.

Die Vergrösserung des Gasvolumens, wenn das Gas die Möglichkeit freier Ausdehnung hat, wird dann

$$\Delta V = \frac{J r^2 \beta}{6K}$$

sein, wo β—der Ausdehnungskoeffizient ist.

Zur Verringerung der Wärmeträgheit muss die aufnehmende Platte nach Möglichkeit dünn genommen werden.

2) Die mittlere Temperaturerhöhung des Gases kann durch volgendes Verfahren gesteigert werden: die aufnehmende Platte wird mittels der Strahlung durchwärmt und wird dann in Bewegung gesetzt; dank der Vermischung des Gases wird die mittlere Temperaturerhöhung eine grössere sein, als im Falle eines stationären Prozesses bei einer unbeweglich ruhenden Platte.

3) Die Trägheit des Radiometers kann durch folgendes Verfahren ausserordentlich verringert werden. Der Behälter wird mit einem die Strahlung absorbierenden Gas angefüllt, seine Wandungen werden von innen mit Ausnahme einer kleiner Öffnung, die mit einem für die Strahlung durchsichtigen Fenster geschlossen ist, versilbert. Die Strahlung wird auf das Fenster konzentriert, tritt in den Behälter ein, wird mehrfach reflektiert, vom Gas absorbiert und geht in Wärme über. Auf diese Weise ist der kleine, von innen versilberte Behälter einem langen Absorptionsgefäss gleichwertig. Es muss ein Gas mit einer grossen Anzahl von Absorptionsbanden angewandt werden; es kann auch ein Gemisch von mehreren Gasen benutzt werden. Für den Fall eines stationären Prozesses wird bei diesem Verfahren der Umwandlung der Strahlung in Wärme die mittlere Temperaturerhöhung des Gases, wie es die Berechnung ergibt,

$$\Delta T = \frac{J}{20\pi K r}$$

sein.

Bei Reflektierung der Strahlung von der Silberoberfläche muss selbstredend ein gewisser Energieverlust stattfinden, so dass die wirklicheTemperaturerhöhung kleiner als die theoretische sein wird.

Dank dem Fehlen einer aufnehmenden Platte, die eine vermittelnde Rolle spielt, wird die Trägheit eines solchen Radiometers minimal sein; seine Wirkung kann deshalb auf einem nicht stationären Prozess beruhen. Wo die Trägheitslosigkeit eines Empfängers wesentlich ist, kann dieses Verfahren Verwendung finden.

Die hier dargelegten Betrachtungen sind nachgeprüft und experimentell bestätigt worden; die Einzelheiten werden an anderer Stelle dargelegt werden.

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GEOPHYSICS

MATHEMATICAL THEORY OF FRONT SHIFTING IN THE ATMOSPHERE *

By I. KIBEL

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We consider the motion of two air masses separated from each other by a frontal surface, a motion involving non-linear deformations and displacements of that surface. The motions are assumed to be «zonal», i. e. all the meteorological elements, as well as the equation of the front surface, are supposed to depend only on two coordinates (y, z) and time (t). An allowance is made for the force of gravity as well as for the Coriolis force; the presence of the earth's surface, assumed to be a plane, is also taken into account. We neglect vertical acceleration $\frac{dw}{dt}$ as compared with the acceleration of gravity (g) and assume the horizontal components of velocities to be independent of z (vertical coordinate). No other limitations are introduced; the motion may be vertical, the density may be variable, and the medium, either barotropic or barocline.

The equations of motion assume the form:

$$\frac{\partial u_i}{\partial t} + v_i \frac{\partial u_i}{\partial y} - 2\omega v_i = 0,$$

$$\frac{\partial v_i}{\partial t} + v_i \frac{\partial v_i}{\partial y} + 2\omega u_i = -\frac{\partial q_i}{\partial y} = -\frac{1}{\rho_i}\frac{\partial p_i}{\partial y},$$

$$g = -\frac{1}{\rho_i}\frac{\partial p_i}{\partial z},$$

[p_i being pressure, ρ_i density, ω projection on axis z of the angular velocity of the earth's rotation, $q_i = q_i(y, t)$ — a new unknown function, $i = 1$ for a «warm» mass, $i = 2$ for a «cold» mass]. Then p_i and ρ_i may be determined from the relations:

$$p_i = \pi_i(q_i - gz;\ t); \quad \rho_i = \frac{\partial \pi_i}{\partial q_i},$$

where $\pi_i(q_i - gz;\ t)$ are arbitrary functions of two arguments and characterize the condition of the air in either medium. The equation of

* A brief outline of the paper to be published in full in the Transactions of the Main Geophysical Observatory (Leningrad).

continuity makes it possible to determine w_1 and w_2 as:

$$g\rho_1 w_1 = \frac{\partial}{\partial t}[\pi_1(q_1 - gz;\ t) - \pi_1(q_1;\ t)] + \frac{\partial}{\partial y}\varphi_1(y,\ t)[\pi_1(q_1 - gz;\ t) - \pi_1(q_1;\ t)],$$

$$g\rho_2 w_2{}^* = \frac{\partial}{\partial t}\pi_2(q_2 - gz;\ t) + \frac{\partial}{\partial y}[\varphi_2(y,\ t)\pi_2(q_2 - gz;\ t)].$$

The presence of the frontal surface brings us to the conditions

$$\pi_1(q_1 - g\zeta;\ t) = \pi_2(q_2 - g\zeta;\ t),$$

$$\frac{\partial}{\partial t}[\pi_1(q_1 - g\zeta;\ t) - \pi_1(q_1;\ t)] = -\frac{\partial}{\partial y}\varphi_1(y,\ t)[\pi_1(q_1 - g\zeta;\ t) - \pi_1(q_1;\ t)],$$

$$\frac{\partial}{\partial t}\pi_2(q_2 - g\zeta;\ t) = -\frac{\partial}{\partial y}[\varphi_2(y,\ t)\pi_2(q_2 - g\zeta;\ t)]$$

[$z = \zeta(y,\ t)$ being an unknown equation of the frontal surface], and this enables us to introduce two functions $\psi_1(y,\ t)$, $\psi_2(y,\ t)$ from the relations:

$$\pi_1(q_1;\ t) - \pi_1(q_1 - g\zeta;\ t) = \frac{\partial\psi_1}{\partial y};\quad \varphi_1\frac{\partial\psi_1}{\partial y} = -\frac{\partial\psi_1}{\partial t},$$

$$\pi_2(q_2;\ t) = \frac{\partial\psi_2}{\partial y};\quad \varphi_2\frac{\partial\psi_2}{\partial y} = -\frac{\partial\psi_2}{\partial t};$$

it being possible to find the u_i 's from the formula

$$u_i = 2\omega y + \Phi_i(\psi_i)$$

where Φ_i is a function determined by the initial data.

The problem is reduced to the solution of a system of equations:

$$\left.\begin{aligned}\left[-RT_0\left(1 - \frac{p}{p_0}\right) + \varphi_1^2\right]\frac{\partial^2\psi_1}{\partial y^2} - RT_0\left(1 - \frac{p}{p_0}\right)\frac{\partial^2\psi_2}{\partial y^2} + 2\varphi_1\frac{\partial^2\psi_1}{\partial t\,\partial y} + \frac{\partial^2\psi_1}{\partial t^2} = \\ = 2\omega u_1 p_0\left(1 - \frac{p}{p_0}\right);\\ -RT_0\frac{p}{p_0}\frac{\partial^2\psi_1}{\partial y^2} + \left[-R\left(T_0\frac{p}{p_0} + T_2 - T_1\right) + \varphi_2^2\right]\frac{\partial^2\psi_2}{\partial y^2} + \\ + 2\varphi_2\frac{\partial^2\psi_2}{\partial y\,\partial t} + \frac{\partial^2\psi_2}{\partial t^2} = 2\omega u_2 p,\end{aligned}\right\} \quad (A)$$

where R is the gas constant. $p_0(y,\ t)$ and $T_0(y,\ t)$ are respectively, pressure and temperature on the earth's surface, $p = p(y,\ t)$ is pressure along the frontal surface, $T_1(y,\ t)$ and $T_2(y,\ t)$ are temperature in the first and the second mass along the frontal surface (all these functions being defined by $\frac{\partial\psi_1}{\partial y}$, $\frac{\partial\psi_2}{\partial y}$, t if the π_1 's are known as functions of their arguments). System (A) is a system of the hyperbolic type and has, under meteorologically interesting conditions, 4 families of real characteristics. In the plane $(y,\ t)$, the direction $\frac{dy}{dt}$ of the characteristics is to be found from an algebraic equation of the 4th degree:

$$\left(\frac{\partial y}{\partial t} - \varphi_1\right)^2\left(\frac{\partial y}{\partial t} - \varphi_2\right)^2 - R\left[\left(\frac{\partial y}{\partial t} - \varphi_1\right)^2\left(T_0\frac{p}{p_0} + T_2 - T_1\right) + \right.$$
$$\left. + \left(\frac{\partial y}{\partial t} - \varphi_2\right)^2 T_0\left(1 - \frac{p}{p_0}\right)\right] - R^2 T_0\left(1 - \frac{p}{p_0}\right)(T_2 - T_1) = 0.$$

* We assume the second medium to be limited by the front, by a free surface and by the surface of the earth.

Two roots of this equations have a magnitude of the order of 10^2 m/sec, and two other, of the order of $10^0 - 10^1$ m/sec. The charecteristics corresponding to these latter roots may serve as new coordinate lines (λ, μ).

The derivatives with respect to time of the four functions p_0, p, $\varepsilon = \frac{\nu_1 + \nu_2}{2}$, $\nu = \frac{\nu_2 - \nu_1}{2}$ taken along λ and along μ will be connected by four relations:

$$\left[\xi^3 - 2\nu\xi^2 - RT_0\xi + 2RT_0\nu\left(1 - \frac{p}{p_0}\right)\right]\left(\frac{d\ln p}{\partial t}\right)_{\lambda,\mu} + RT_0\xi\left(\frac{d\ln p_0}{dt}\right)_{\lambda,\mu} +$$
$$+ \xi^2\left(\frac{d\varepsilon}{dt}\right)_{\lambda,\mu} + \left[\xi^2 - 2RT_0\left(1 - \frac{p}{p_0}\right)\right]\left(\frac{d\nu}{dt}\right)_{\lambda,\mu} =$$
$$= 2\omega\left[(u_2 - u_1)\,RT_0\left(1 - \frac{p}{p_0}\right) - u_2\xi^2\right];$$
$$(2\nu - \eta)\left(\frac{d\ln p}{dt}\right)_\lambda + \left(\frac{d(\varepsilon + \nu)}{dt}\right)_\lambda = (2\nu - \xi)\left(\frac{d\ln p}{dt}\right)_\mu + \left(\frac{d(\varepsilon + \nu)}{dt}\right)_\mu;$$
$$[R(T_2 - T_1) - \xi(\xi + \eta) + 2\nu(\eta + 2\xi) - 4\nu^2]\left(\frac{d\ln p}{dt}\right)_\lambda +$$
$$+ R\left(\frac{d\ln p_0}{dt}\right)_\lambda + \xi\left(\frac{d(\varepsilon + \nu)}{dt}\right)_\lambda + 2\omega u_2\xi =$$
$$= [R(T_2 - T_1) - \eta(\xi + \eta) + 2\nu(\xi + 2\eta) - 4\nu^2]\left(\frac{d\ln p}{dt}\right)_\mu +$$
$$+ R\left(\frac{d\ln p_0}{dt}\right)_\mu + \eta\left(\frac{d(\varepsilon + \nu)}{dt}\right)_\mu + 2\omega u_2\eta$$

where

$$\xi = \left(\frac{dy}{dt}\right)_\lambda - \sigma_2; \quad \eta = \left(\frac{dy}{dt}\right)_\mu - \nu_2.$$

Thanks to the existence of these relations, we can give an effective method for a numerical solution of the Cauchy problem for our system of equations (A). If the shape of the frontal surface and the velocities u_i, ν_i and p_0 at the initial moment of time are known, the motion of the air masses and the shape of the frontal surface for any subsequent moment of time t can be determined.

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BIOPHYSICS

BIOLOGICAL EFFECT OF CENTIMETRE WAVES

By S. J. TURLYGUIN

(Communicated by P. P. Lazareff, Member of the Academy, 2. I. 1937)

The action of an electromagnetic field on biological tissues and processes has for a long time attracted the attention of investigators. The waves whose effect has been studied to some extent range from hard X-ray waves to infra-red ones and from decimetre waves to infinitely long (direct current) waves.

The interval between the infra-red (of the order of a fraction of a millimetre) and the decimetre waves remains uninvestigated and we do not know any work concerning this question. The interval covering these 10 octaves must present considerable interest as may be seen from a consideration of the problem of the absorption of energy in connection with the peculiarities of the structure of matter.

As radiators we used a series of centimetre long rectilinears vibrators. Ten such vibrators were placed in series and were excited by the spark of a resonance transformer of 100 000 volts. The wave of such a system is about 2 centimetres long and contains approximately 80 per cent of the total energy, the remaining 20 per cent belonging to the higher frequencies. The spectral analysis of the beam has not yet been made. The total energy of the frequency in question did not exceed a fraction of a milliwatt, the absorbed energy being only a small fraction of the total energy. Therefore, a thermal action was out of the question.

Aster seeds, either dry or soaked during 24 hours were experimented on; 70 per cent of the seeds germinated.

After a series of experiments had been made, it was decided to use the strongest fields, which arise in the immediate proximity of the spark, without taking into consideration the fact that there will be present there, not only the fields of the frequency that is of interest to us, but also a field of the frequency of the diathermic plant feeding the generator, which shows no specific effect. The field near the spark is similar to that of the condenser. The intensity of such a field is many times greater than that of the radiated field of a vibrator.

The scheme of the experiments was as follows: 10 vibrators were placed in one line on a horizontal glass plate. One row of the seeds was placed under the plate, in front of the spark, the other row was placed on the plate, at some distance from the spark, this row being perpendicular to the common axis

of the vibrators; the purpose of this arrangement was to keep the heat of the spark away from the seeds.

In order to eliminate the strong field of diathermic frequency, another scheme was resorted to. A second row of vibrators, which were excited by the radiation of the first, was placed, together with the seeds, on the same glass plate. When the seeds had been exposed to the action of the fields, they were planted in transverse rows in a long box. After the lapse of some time (10—15 days), the plants were plucked and weighed. The average weight of one plant showed the effect of the fields used.

The results are shown in the tables.

Nos of series	Conditions of the experiment	Exposure in seconds	Condition of the seeds	Number of plants grown	Total weight of plants in mg	Average weight of one plant in mg
		First box: Planted 16/IV; weighed 25 IV				
1	In the immediate proximity of the spark separated by a glass plate	—	Soaked	6	520	87
		—	Dry	5	480	96
		—	»	6	400	80
2	At some distance from the spark, without a glass plate (9 seeds at a time)	1	Soaked	7	700	100
		15	»	7	780	112
		30	»	8	620	77.5
		60	»	8	860	107.5
3	At some distance from the spark, without a glass plate (9 seeds at a time)	1	Dry	5	500	100
		15	»	7	580	80
		30	»	6	420	70
		60	»	6	470	78.5
4	Near the second vibrators excited by radiation (10 seeds at a time)	1	Soaked	4	300	75
		15	»	8	680	85
		30	»	8	620	77.5
		60	»	8	680	85
5	Near the second vibrators excited by radiation (10 seeds at a time)	1	Dry	9	880	98.5
		15	»	5	480	96.0
		30	»	6	640	107.0
		60	»	9	700	78.0
6	Control	—	Soaked	5	260	52
		—	»	4	240	60
		—	Dry	8	420	52.5
		—	»	6	500	83.5

The ratio of the average weight of all the exposed plants to the average weight of the control plants was $\frac{88.4}{61.7} = 1.43$

If we drew a graph of the results obtained we should notice that the points indicating the weight of the exposed plants are generally higher than those of the control plants, which justifies us in concluding that the biological effect of fields with a frequency of $1.5 \cdot 10^{10}$ cycles is present even at such an extremely small power as a fraction of a milliwatt. The role of the exposure becomes clear when we compare the figures of the different series for example those of series Nos 2, 3, 8, 10, and so on. It should be noted that no complete identity of the effect of the exposure in the different series is to be observed, although an exposure of 30 seconds results in a minimum nearly everywhere. It is yet premature to argue about the mechanism of the action of the centimetre waves on the basis of the above-mentioned experi-

Nos of series	Conditions of the experiment	Exposure in seconds	Condition of the seeds	Number of plants grown	Total weight of plants in mg	Average weight of one plant in mg
	Second box: Planted 27/IV; weighed 11/V					
7	At some distance from the spark, without a glass plate (9 seeds at a time)	1	Soaked	8	860	107
		15	»	8	780	98
		30	»	7	480	68.5
		60	»	8	600	75
8	At some distance from the spark, without a glass plate (9 seeds at a time)	1	Dry	5	280	56
		15	»	7	600	86
		30	»	8	560	70
		60	»	7	520	74
9	Near the second vibrators excited by radiation (10 seeds at a time)	1	Soaked	7	590	84.5
		15	»	7	560	80.0
		30	»	8	660	82.5
		60	»	6	400	67
10	Near the second vibrators excited by radiation (10 seeds at a time)	1	Dry	9	720	80
		15	»	8	780	98
		30	»	9	700	78
		60	»	3	300	100
11	Control*	—	Soaked	5	460	92
		—	»	4	260	65
		—	Dry	8	600	75
		—	»	7	300	43

* The ratio of the average weight of all the exposed plants to the average weight of the control plants was $\frac{80.2}{67.5} = 1.18$

Nos of series	Conditions of the experiment	Exposure in seconds	Condition of the seeds	Number of plants grown	Total weight of plants in mg	Average weight of one plant in mg
	Third box: Planted 13/VI; weighed 2/VIII					
12	Near the spark: separated by a glass plate (9 seeds at a time)	1	Soaked	7	800	114.2
		15	»	4	540	135
		30	»	3	260	86.6
		60	»	6	720	120
13	Near the spark; separated by a glass plate (9 seeds at a time)	1	Dry	6	880	146.6
		15	»	5	560	112
		30	»	4	340	85
		60	»	5	600	120
14	Near the second vibrators excited by radiation (10 seeds at a time)	1	Soaked	5	600	120
		15	»	10	1 100	110
		30	»	7	960	137.1
		60	»	4	460	115
15	Near the second vibrators excited by radiation (10 seeds at a time)	1	Dry	4	620	155
		15	»	4	600	150
		30	»	8	400	112.5
		60	»	7	760	108.5
16	Control*	—	Soaked	4	260	650
		—	»	6	580	96.6
		—	Dry	8	740	92.5
		—	»	5	480	96.0

* The ratio of the average weight of all the exposed plants to the average weight of the control plants was $\frac{120.4}{89.5} = 1.34$

ments, but it may be definitely stated that thermal effect plays no part in it, and that, therefore, the effect of these waves should be regarded as specific (of the type of the photochemical effect).

Conclusions

A generator was assembled whose oscillating frequency reached approximately $1.5 \cdot 10^{10}$ cycles ($\lambda \approx 2$ cm).

Experiments were made for the purpose of studying the effect of these oscillations on the seeds of asters. It has been found that, in spite of the power of the generator being very small—a fraction of a milliwatt—the oscillations affect the seeds, accelerating the growth of the plants by about 20—45 per cent as compared with the control. A certain regularity in the influence of the exposure has been observed.

The biological effect of centimetre waves has been proved.

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BIOPHYSIK

ÜBER DAS GESETZ DER NERVENREIZUNG DURCH WECHSELSTRÖME

Von N. N. MALOV

(Vorgelegt von P. Lasareff, Mitglied der Akademie, d. 21. I. 1937)

Die von Nernst (1) und Lasareff (2) entwickelte Ionentheorie der elektrischen Reizung nimmt an, dass die von dem elektrischen Strom hervorgerufene Reizung durch die Änderungen der Ionenkonzentration an halbdurchlässigen Membranen bedingt ist.

In dieser Theorie geht man von den bekannten Diffusionsgleichung aus:

$$\frac{\partial c}{\partial t} = k \frac{\partial^2 c}{\partial x^2}, \tag{1}$$

wo c — die Konzentration und k — den Diffusionskoeffizient bedeutet. Die x-Achse, die senkrecht auf der Membranfläche steht, fällt mit der Stromrichtung zusammen.

Wenn die von einem sinusoidalen Strom geschaffene Konzentrationsänderung dem Diffusionsprozess entgegenwirkt, und wenn man die Länge des Nerven als unendlich gross betrachtet, so ist die minimale Stromstärke, die einen kaum bemerkbaren Reiz hervorruft, mit der Frequenz f durch folgende Gleichung verknüpft (Nernst):

$$I = A\sqrt{f}, \tag{2}$$

wo A eine Konstante ist.

Dieses Gesetz ist bei tiefen Frequenzen ($f < 3000$ Hz) erfüllt (3). Bei hohen Frequenzen aber ($f > 20$ Khz) erhält man annähernd die Beziehung

$$I = A_1 f, \tag{3}$$

wie der Verfasser und Rževkin experimentell gezeigt haben (4,5).

Die Messwerte sind in der Abbildung durch Ecken, Kreise und Kreuze angegeben.

Um das Gesetz (3) zu erklären, setzte Lasareff (6) voraus, dass bei hohen Frequenzen die Wirkung der Diffusionsprozesse keine bedeutende Rolle spielt. Die Integration der Gleichung (1) gibt in diesem Falle das Gesetz (3). Für die erwähnte Messungen gab er die empirische Formel:

$$I\left[\frac{6e^{-4\cdot 10^{-5} f}}{\sqrt{f}} + \frac{500}{f}\right] = 1, \tag{4}$$

die bei hohen Frequenzen in gutem Einklang mit den Messungen steht; bei tiefen Frequenzen finden merkliche Abweichungen statt, da diese

Formel dann nicht das Nernst'sche Gesetz gibt. Die Formel (4) ist in der Abbildung dargestellt (Kurve L).

Hill (7) berücksichtigte den endlichen Abstand a zwischen den Membranen und fand, dass die Konzentration (in einem Schnitte in der Entfernung x von der Membrane) gleich ist

$$c = c_0 \pm \frac{AI}{p} \frac{1}{\sqrt{1 + 2e^{-p}\cos p + e^{-2p}}} \left[e^{-\frac{px}{a}} \cos\left(\zeta - p\frac{x}{a}\right) - \right.$$
$$\left. - e^{-p\frac{a-x}{a}} \cos\left(\zeta - p\frac{a-x}{a}\right) \right], \qquad (5)$$

wo A eine Konstante, c_0 die anfängliche Konzentration, $p = a\sqrt{\frac{\pi}{k} f}$, $\zeta = 2\pi ft + \varphi$ und φ eine von x unabhängige Grösse bedeuten.

Bei grossen p erhält man aus dieser Gleichung zwar das Nernst'sche Gesetz, aber das Gesetz (3) bleibt ganz unerklärt.

Es ist möglich, eine gute Übereinstimmung der Theorie mit den Messergebnissen in einem weiten Frequenzbereich zu erhalten, wenn man annimmt, dass für die Reizung nicht die Konzentrationsänderung an der Membrane, sondern die mittlere Konzentrationsänderung längs einer Strecke $(0, x_1)$ wichtig ist, wobei $x_1 \ll a$.

In diesem Falle kann man das zweite Glied des Klammerausdruckes fortlassen. Somit erhalten wir anstatt (5) die Gleichung:

$$c = c_0 \pm \frac{AI}{p} \frac{1}{\sqrt{1 + 2e^{-p}\cos p + e^{-2p}}} e^{-p\frac{x}{a}} \cos\left(\zeta - p\frac{x}{a}\right).$$

Die mittlere Konzentration längs der Strecke $(0, x_1)$ ist gleich:

$$\bar{c} = \frac{1}{x_1}\int_0^{x_1} c\,dx = c_0 \pm \frac{Aa\sqrt{2}}{x_1} \frac{I}{p^2\sqrt{1 + 2e^{-p}\cos p + e^{-2p}}} \left[\cos\left(\frac{\pi}{4} - \zeta\right) - \right.$$
$$\left. - e^{-p\frac{x_1}{a}} \cos\left(\frac{\pi}{4} - \zeta + p\frac{x_1}{a}\right) \right]. \qquad (6)$$

Für die Reizung soll die mittlere Konzentrationsänderung einen Wert

$$\bar{c} - c_0 = B$$

erreichen. Nehmen wir an, dass $\zeta = \frac{\pi}{4}$, so finden wir folgende Gleichung für das Reizungsgesetz:

$$I = Dp^2 \frac{\sqrt{1 + 2e^{-p}\cos p + e^{-2p}}}{1 - e^{-p\frac{x_1}{a}}\left(\cos p\frac{x_1}{a}\right)}, \qquad (7)$$

wo

$$D = \frac{Bx_1}{Aa\sqrt{2}} = \text{const.}$$

ist.

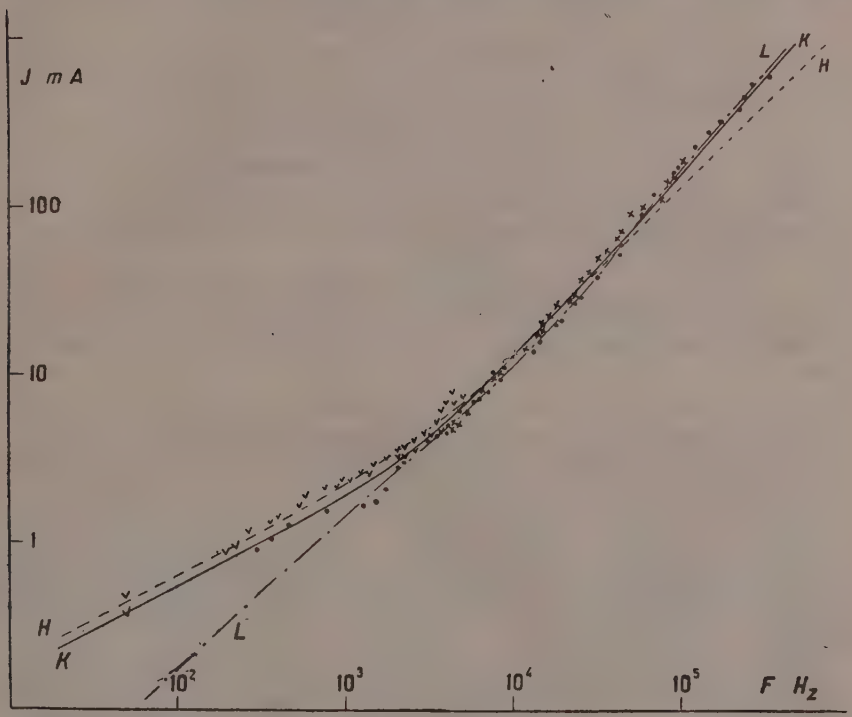
Die Messungsergebnisse kann man mittels der Gleichung

$$I = 2.44 \cdot 10^{-3} p^2 \frac{\sqrt{1 + 2e^{-p}\cos p + e^{-2p}}}{1 - e^{-0.03p}\cos(0.03\,p)} \qquad (8)$$

darstellen, wo $p = 0.75\sqrt{f}$ und $\frac{x_1}{a} = 0.03$ ist; (sieh in der Abbildung Kurve H).

Aus der Gleichung (8) kann man dien beiden Gesetze (3) und (4), als Grenzfälle für tiefe und hohe Frequenzen erhalten.

Es ist möglich, eine noch bessere Übereinstimmung mit den Messungen zu finden, wenn wir unsere Darstellung der Prozesse, die in den



Geweben stattfinden, auf eine breitere Grundlage stellen. Zu diesem Zwecke benutzten wir die Theorie der galvanischen Polarisation, die von Warburg [8] und Krüger [9] entwickelt wurde.

Diese Verfasser hatten gezeigt, dass man ausser der Diffusion noch die Bildung der Doppelschichten berücksichtigen muss, da ein Teil der Ionen für die Bildung dieser Schichten notwendig ist. Diese Annahme führt zu anderen Grenzbedingungen für die Gleichung (1); die Integration gibt für die Grösse der Konzentration (in einem Schnitte in der Entfernung x von der Membrane) folgenden Ausdruck:

$$c = c_0 \pm A \frac{\sin \vartheta}{\sqrt{f}} I e^{-x\sqrt{\frac{\pi}{k}f}} \cos\left(\zeta - x\sqrt{\frac{\pi}{k}f}\right), \qquad (9)$$

wo

$$\operatorname{tg} \vartheta = \frac{1}{1 + N\sqrt{f}}, \quad \zeta = 2\pi f t + \vartheta$$

und A, N—Konstanten sind.

Berechnen mir nun die mittlere Konzentrationsänderung längs der Strecke $(0, x_1)$, setzen $\zeta = \frac{\pi}{4}$ ein und nehmen an, dass für die Reizung die Konzentrationsänderung

$$\bar{c} - c_0 = B$$

notwendig ist, so finden wir für das Reizungsgesetz:

$$I = Df \frac{\sqrt{1 + (1 + N\sqrt{f})^2}}{1 - e^{-\alpha\sqrt{f}} \cos(\alpha\sqrt{f})}, \tag{10}$$

wo D und $\alpha = x_1 \sqrt{\frac{\pi}{k}}$ konstante Grössen sind.

Die Messungen kann man darstellen mittels der Gleichung:

$$I = 8.5 \cdot 10^{-4} f \frac{\sqrt{(1 + 2 \cdot 10^{-3}\sqrt{f})^2 + 1}}{1 - e^{-0.0225\sqrt{f}} \cos(0.0225\sqrt{f})}. \tag{11}$$

Diese Kurve ist in der Abbildung mit K bezeichnet.

Aus der Gleichung (10) sieht man, dass bei tiefen Frequenzen

$$I_1 = \frac{D\sqrt{2}}{\alpha}\sqrt{f} = D_1\sqrt{f} \tag{12}$$

wird, d. h., wir erhalten das Gesetz von Nernst.

Bei mittleren Frequenzen, wenn $e^{-\alpha\sqrt{f}} \ll 1$, aber $N\sqrt{f} < 1$, finden wir annähernd:

$$I_2 = D\sqrt{2}f = D_2 f, \tag{13}$$

d. h., das vom Verfasser und Rževkin gefundene Gesetz (4).

Bei noch höheren Frequenzen, wenn $N\sqrt{f} \gg 1$ wird, erhalten wir ein neues Gesetz:

$$I_3 = DNf^{3/2} = D_3 f^{3/2}. \tag{14}$$

Leider konnten wir nicht bei diesen hohen Frequenzen arbeiten, da die Wärmeentwicklung, die durch die bei hohen Frequenzen ziemlich starken Reizströme auftritt, die Messungen bei Frequenzen, die 320 Khz übersteigen, erschwert.

Abschliessend ist zu bemerken, dass das Gesetz (10) am besten zutrifft. Die Messungen des Widerstandes und der Kapazität des menschlichen Körpers ([10]) zeigen nämlich, das die Frequenzabhängigkeit des Ohm'schen Widerstandes, sowie auch der Kapazität des Körpers sehr kompliziert ist und durch die reine Diffusionstheorie, wie sie Nernst und Hill benutzen, nicht erklärt werden kann.

Die Warburg-Krügersche Theorie gestattet aber, wie später gezeigt werden soll, diese komplizierten Erscheinungen zu erklären.

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BIOCHEMISTRY

THE CURVE OF «RACEMIZATION» OF PROTEINS FROM THE MUSCLES OF CERTAIN INVERTEBRATES

By I. LEONTJEV and K. MARKOVA

(Communicated by N. Zelinskij, Member of the Academy, 9. I. 1937)

Dakin ([1]) was the first who noted a decrease in the optical activity (specific rotation) of proteins when placed in weak solutions of alkali. He also showed that when the specific rotation of such protein solutions has attained a certain value (considerably lower than the initial one), it remains constant. In order to explain the mechanism of this process, called «racemization», Dakin advanced the theory that the change of optical activity of proteins under the action of alkalis was due to ketoenol tautomerism*. Later on «racemization» was used for the differentiation of proteins in general ([4], [5]). Further investigation showed that each protein has a definite rate of «racemization», which can be expressed by a corresponding curve. The difference of identity of two, three, and so on, proteins can be judged from the behaviour of their respective curves. In this way, a number of authors have been able to show the identity of proteins of different origin ([6–10], [24]). The results thus obtained are in excellent agreement with those obtained from chemical analysis ([11–13]). Finally, quite recently, a comparative study of the curves of «racemization» of the globulins of the seed of three species of *Cucurbitaceae* made it possible to postulate the identity of these proteins ([14]). This fact is confirmed by all the data (chemical, physical, biological, etc.) proving the identity of the globulins of the seeds of all cucurbitaceous plants ([16–19]). Complete identity of the curves of «racemization» was also obtained in the case of special protein praparations isolated from various sources ([20]). The analogy in the behaviour of the curves of «racemization» of these proteins coincides with their chemical and physical indices. All this material was a stimulus to a study of the little studied curves of «racemization» of proteins of the muscles of the invertebrates, all the more since certain species of these animals, principally, marine species, have great economic importance ([21]).

With this purpose in mind, the muscles of the following animals were taken for experiment: 1) *Cucumaria frondosa* Gunn., a representative of the *Echinodermata*; 2) *Pecten islandicus* Müll., a representative of the *Mollusca* and 3) *Potamobius fluviatilis* L., a representative of the *Crustaceae*.

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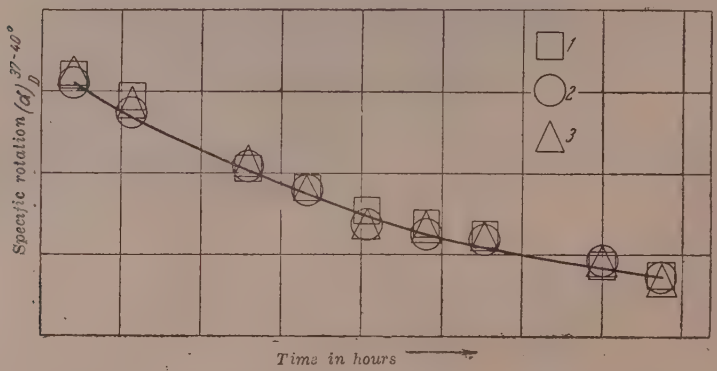
* This theory, especially at the present time, is being disputed ([2], [3]).

Table 1

Muscle protein \ Time in hours	1	24	48	72	96	120	144	168	192	216	240
Potamobius fluviatilis	—63.0	—59.0	—	—46.6	—42.3	—38.0	—36.0	—33.8	—	—28.0	—26.0
Pecten islandicus	—61.6	—56.0	—	—46.7	—41.9	—36.0	—34.0	—33.0	—	—28.8	—26.0
Cucumaria frondosa	—63.2	—58.0	—	—48.0	—42.0	—36.0	—35.2	—34.0	—	—29.0	—25.4



1—Potamobius fluviatilis, 2—Pecten islandicus, 3—Cucumaria frondosa.

Table 2

	Indices	Protein from muscles		
		Potamobius	*Cucumaria*	*Pecten*
Chemical	Moisture	3.13	3.19	3.20
	Ashes	0.43	0.48	0.50
	Titration value	8.5	8.6	8.6
	Oxidation value	7.4	7.4	7.4
	Total nitrogen	15.95	15.75	15.65
	Tyrosine	5.30	5.08	4.67
	Tryptophane	1.56	1.71	1.58
	Arginine	4.6	4.4	—
Physical	Density	1.0025	1.0030	1.0040
	Electrical conductivity	58.40×10^{-5}	61.80×10^{-5}	66.75×10^{-5}
	Surface tension (dyne/cm)	63.6	61.7	66.6
	Viscosity (dyne/cm)	0.021	0.032	0.013
	Refraction	1.3352	1.3350	1.3351
	Iso-point	4.7	4.7	4.7

In studying their curves of «racemization», (t=37—40° C) the concentration of the solutions of the muscle proteins (in $n/2$ NaOH) was 1 per cent*.

The experiment showed that the trend of the curves of «racemization» of all three proteins was absolutely the same (Table 1 and Figure).

These results are confirmed by chemical and physical analysis of the proteins (Table 2).

Conclusions

1. By means of definite solutions of NaOH, protein preparations may be extracted from the muscles of *Potamobius fluviatilis* L., *Cucumaria frondosa* Gunn. and *Pecten islandicus* Müll., whose curves of «racemization» coincide.

2. The similarity of the curves of «racemization» of these proteins is in accord with the chemical and physical indices of the substances.

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* The method of making the protein preparations from muscular tissues of invertebrates which we used here differs fundamentally from that ordinarily employed in work with invertebrates ([22]) and is described elsewhere ([23]).

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BIOCHEMISTRY

ABSORBER FOR ACETIC ALDEHYDE DETERMINATION

By J. V. RAKITIN

(Communicated by A. A. Richter, Member of the Academy, 17. I. 1937)

One of the most important points to be considered in connection with the accuracy of most of the available methods of biochemical investigation based on the determination of acetic aldehyde is the prevention of losses involved in the separation of that highly volatile substance. In acetic aldehyde determinations by the methods of Neuberg ([3]), Ripper ([5]) and some others, these losses are reduced by ice-cooling the receivers intended for the distilled liquid. If cooling during distillation does in effect prevent great losses, certain losses are found to occur in the course of subsequent manipulations needed to determine the aldehyde in the distillate. Such advantages as may be afforded by distilling the aldehyde into ice-cold water are certainly outbalanced by those pertaining to the method of distilling the aldehyde into cooled sulphate solutions, since the latter readily tie up the aldehyde into a non-volatile aldehyde-sulphite compound.

This advantage is made use of in determining lactic acid after Friedmann, Cotonio and Schaffer ([8]), in determining acetic aldehyde after Gustavson ([4]), etc.

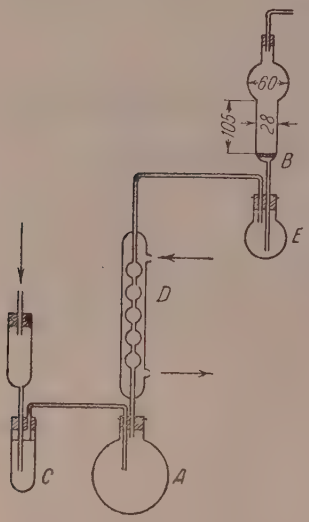
While, in catching aldehyde by Gustavson's method, the sulphite solution is cooled with ice, the catching of aldehyde by Friedmann's method is conducted at ordinary temperature. Friedmann's scheme may be described as follows: The acetic aldehyde formed by the action of potassium manganate on lactic acid is forced by the current of air and water vapour out of the distilling flask and into a back-flow condenser, where the water vapour becomes condensed, while the easily-volatilized acetic aldehyde is drawn, together with the air, into the absorbing column, where it combines with the bisulphite. To avoid considerable losses in catching the aldehyde, the jet of air is broken up in impinging upon the minute glass beads filling the absorption column.

The above method, widely used in blood investigations, was employed by Valužič ([1]) for determining lactic acid content in wine. The appliance of Friedmann, Cotonio and Schaffer was also used by Agabaliants and Savenkova ([9]) for the iodometric semi-micromethod of aldehyde determination in wine developed by them.

The accuracy and simplicity of this method of aldehyde determination has enabled us to use it in catching the acetic aldehyde when determining

the activation of carboxylase, in distilling aldehyde from tomato fruit ([6]), from potato tubers ([7]) and in other cases.

Hundreds of analyses made for the purpose of aldehyde determination by this method suggested the necessity of some improvements of the method as used by Agabaliants and Savenkova. These improvements, which increases the accuracy of the method and the speed of the analysis, are based on the replacement of the absorbing column, where the breaking up of the air jet is produced by its impact against the glass beads, by an absorber, where the pulverizing of air into minute bubbles is affected by drawing it through a plate of pressed porous glass. The pulverizing portion of the absorber consisted of glass filter No. 1. With a view to increasing the pulverizing action of the plate, 1—2 drops of butyl alcohol were introduced into the absorber to reduce the surface tension of the liquid. The idea of employing butyl alcohol was borrowed from A. A. Richter ([4]). The new jet-breaker combines with the butyl alcohol in creating a vast absorption area (during the drawing of the air, the contents of the absorber become one mass of foam composed of minute bubbles), which, at a suitable velocity of air flow, and with a certain addition of bisulphyte, results in a complete absorption of the aldehyde.



The whole appliance, when assembled, is as shown in the figure. The dimensions of the absorber are given in mm.

Procedure Used in the Determination. The sample under examination is placed in a distilling flask *A*, 10 cm³ 0.5% $NaHSO_3$ and 1—2 drops of butyl alcohol being poured into the absorber *B*. A connection is then made with the cooler *D* and with a water-jet pump, which force air through the appliance at a rate of 30 litres per hour. The heating of the distilling flask is then started. The air-bubbles, passing through the water contained in test-tube *C* show that neither gases nor vapour can escape from the flask *A* through the inlet. The drawing of air is stopped five minutes after the contents of retort *A* have begun to boil. In the course of distillation, the highly-volatile aldehyde does not condense and is drawn into the absorber, where it combines with the bisulphate. Upon distillation, the absorber is washed down with distilled water, which collects in the receiver *E*. The excess of bisulphite is then titrated, first roughly with 0.1 *n* solution of iodine, whereafter a few drops of 1% solution of starch is added, the remaining bisulphite being ultimately titrated with 0.01 *n* iodine until it assumes a light-blue colour. The quantity of iodine consumed in titrating is not taken into account. In case of retitration, the excess of iodine is titrated with 0.01 *n* hyposuphite.

In order to dissociate the aldehyde-sulphite compound, about 2 cm³ of a saturated sodium bicarbonate solution is added to the reacting mixture. The bisulphite due to the action of the bicarbonate is titrated with 0.01 *n* iodine.

One cubic centimetre of 0.01 *n* iodine corresponds to 0.22 mg of acetic aldehyde. After determining the aldehyde in the sample under examination,

a control determination is made (distilled water used instead of the substance tested). The results of the control determination are deducted from the data obtained with the substance under examination.

One may judge of the operation of the appliance from the figures given below.

The initial material used in the distillation of acetic aldehyde in our experiments was Russian beer, 25 cm³ of beer being used in every determination. The samples of beer used are numbered.

The first series of figures shows the relation between the extent of absorption of the aldehyde at a rate of air-blow of 30 litres per hour and the amount of 0.5% bisulphite contained in the absorber (Beer sample No I).

Beer sample № 1

Amount of 0.5% $NaHSO_3$ in the absorber, cm³	Amount of combined CH_3CHO per 1 cm³ of 0.01 *n* iodine
1.25	1.90
2.5	2.30
5.0	2.35
10.0	2.35
15.0	2.35
20.0	2.35

Beer sample № 2

Rate of air-flow, litres per hour	Amount of combined CH_3CHO per 1 cm³ of 0.01 *n* iodine cm³
15	1.58
30	1.60
60	1.56
90	1.50

These figures show conclusively that, if the available amount of 0.5% $NaHSO_3$ is equal to, or in excess of 5 cm³, it is sufficient to ensure the absorption of all the aldehyde forced through the absorber.

The figures of the second series show the connection between the rate of air-flow and that of absorption of the aldehyde.

All the determinations were made with 10 cm³ 0.5% $NaHSO_3$ in the absorber. The contents of the distilling flask were boiled for a space of five minutes (Beer sample No 2).

The data obtained justify the statement that the most complete absorption of the aldehyde occurs at a rate of air-flow of about 30 litres per hour.

The third series of figures exhibit the relation between the extent of absorption of the aldehyde and the duration of the distillation (Beer sample No 3).

Beer sample № 3

Time elapsed since the liquid began to boil, min	Amount of CH_3CHO per 1 cm³ of 0.01 *n* iodine, cm³
5	2.80
10	2.80
15	2.80

Unripe tomato

Time elapsed since the liquid began to boil min.	Amount of CH_3CHO per 1 cm³ of 0.01 *n* iodine, cm³
5	1.25
10	1.24
15	1.25

A similar picture was observed in distilling aldehyde from unripe tomato fruit (a sample of 50 g plus 50 g distilled water being taken for every determination).

The experiments made enable us to conclude that the best results from the point of view of the completeness of aldehyde absorption that can be obtained with this method, with the modifications suggested above, are attainable with 10 cm³ of 0.5% bisulphite in the absorber, a rate of air-flow of 30 litres per hour, and a five-minute boiling. Should it be necessary to use a large distilling flask (of 1. 5—3 litres capacity), the period of boiling should be increased. The data cited in this paper have been obtained with a distilling flask of 250 cm³ capacity.

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GENETICS

PRODUCTION OF POLYPLOID PLANTS AFTER REGENERATION

II. AUTOTETRAPLOID OF *NICOTIANA GLAUCA*

By G. D. PRATASENJA

(Communicated by N. I. Vavilov, Member of the Academy, 17. I. 1937)

Experimental mastery of the process of converting sterile hybrids into fertile ones and the obtaining of new forms of plants through the somatic doubling of the chromosome number may throw light on the phylogenetic nature of plant organisms and enable us to obtain new forms of plants.

The materials published on the obtaining of polyploid plants[H. Winkler(5), C. A. Jörgensen (1) and others] give no assurance of the possibility of obtaining polyploids in the case of the majority of plants.

While working on the problem of obtaining polyploids and converting the sterile hybrids of *Nicotiana rustica*×*N. tabacum* and *Pelargonium roseum* into fertile plants, we were compelled to modify somewhat the methods of obtaining polyploids in regeneration. By one of these methods, described in our previous article (4), we obtained also an autotetraploid of *Nicotiana glauca*. The essential part of our work of obtaining this autotetraploid was as follows: when leaves of *Nicotiana glauca*, cut at the base of the petiole, were planted, they developed a callus quite well and, after about ten days from the date of planting, they put out roots from the callus. Bearing in mind statements found in literature that in regeneration in calluses of different origin i. e. of the bacterial, hybrid and ordinary one [Magnus, Krenke (3), Kostoff (2)], cells are encountered having a double chromosome number,—it seemed that shoots ought to be obtained directly from the callus or from the roots growing from the callus (*N. glauca* readily grows out roots) and it was be supposed that among such shoots, some would be polyploid.

With this in mind, a hotbed was made early in February, 1935. A nutrient soil layer for the hotbed was prepared of leaf mold mixed with an equal amount of fine, washed sea sand. When the nutrient layer in the hotbed reached a temperature of 18° C (on February 5), leaves of *Nicotiana glauca* cut at the base of the petiole without the axillary bud were planted in it. The bed was watered one or two times in five days. The temperature in the hotbed was maintained at 15 to 18° C, but in the first days of March the temperature of the soil layer of the hotbed reached 40° (the glass had not been whited) and for this reason the hotbed was opened to ventilation. At this time, the temperature of the air in the hotbed fell to +4° and remained at this level

for two days (March 3 to 5), while the temperature of soil at a depth of 5 cm was +15° C. The lowered temperature threatened to kill all the planted material, so that ventilation of the hotbed was discontinued and the temperature rose to +15 C.

On March 23, on some leaves, the cones of growth of the future shoots appeared on the callus.

On April 4, the rooted leaves to the number of 8, with young shoots up to 3 cm long, were transplanted into another place, with ordinary, poorly fertilized soil.

The plants were covered with glass frames for 5 days. During this time, two plants died. When the remaining plants had grown strong, the glass frames were removed, and they were left uncovered, being watered once every day.

The plants began to grow luxuriantly, except one, whose development was somewhat depressed. On examining the stomata of the leaves of all the six plants, it was found that the five luxuriantly growing plants had stomata of equal size, while the stomata of the leaves of the plant whose development was depressed were of much greater size. Careful examination of the external morphology revealed the fact that the lateral veins of the leaf, especially the lower ones, had more acute angles at the point where they branched off the main vein, and that at a certain distance from the branching off point, they made a curve, diverging to the edges of the leaf blade. No other peculiarities of the vegetating plant could be noted.

In the second half of June, the plants formed flower buds. On analysing the reduction division, it was established that all five luxuriantly developing plants had a correct reduction division. In their heterotypical division, the chromosomes were located exactly in the equatorial plate, in which, quite plainly, there could be counted twelve gemini. The weakly developed plant, in its heterotypical division, did not have a correct reduction division. In the methaphase stage, the chromosomes were not located in the same plane and consequently could not be accurately counted. However, it was apparent that in this stage they were more than 12 (up to about 20 and sometimes even more). When the flowers had opened, it was unmistakably to be seen that the size of this plant's flowers exceeded the size of the flowers of the other five. This plant did not form a seed vessel at the beginnig of its flowering, either with self-pollination or with free pollination; but in October, seeds began to form from flowers freely pollinated; with self-pollination in a parchment isolator no seeds developed, just as in the summer.

On the 5th of November, slips were cut from this plant and from the other, luxuriantly developing ones and were planted in hotbeds. The slips from the luxuriantly developing plants rooted after 15 to 20 days; slips from the weakly developed plant grew, but only in March, 1936, did one of them put out roots, while the others died. On cytological analysis of the rootlets of the rooted slip, 48 chromosomes were counted. Thus, the fact was established that this plant was an autotetraploid of *Nicotiana glauca*. On sowing the seed from the freely pollinated tetraploid of *Nicotiana glauca*, seedlings were obtained which developed quite normally. Cytological analysis of the rootlets from these seedlings showed that they contained 48 chromosomes except one, which was a triploid, containing 36 chromosomes.

When the amphidiploid plant *Nicotiana rustica* × *Nicotiana tabacum* was pollinated with pollen taken from this autotetraploid, as also from the diploid of *Nicotiana glauca*, the vessels with hybrid seed developed equally well. This seed was sown and gave excellent plants, those obtained from the pollination of the amphidiploid (*Nicotiana rustica* × *Nicotiana tabacum*)

with pollen from the tetraploid *N. glauca* differing from those obtained from pollination with pollen from the diploid *N. glauca*. These differences will be described in detail in a later paper.

Conclusions

1. Leaves of *Nicotiana glauca*, cut at the base of the petiole, on being planted, formed a callus at the place of the cut, from which roots and shoots grew.

2. Among the shoots of *Nicotiana glauca* which grew from the callus of the petiole, shoots were found with a double chromosome number.

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GENETICS

STUDIES ON POLYPLOID PLANTS

XVI. *NICOTIANA RUSTICA*×*NICOTIANA TABACUM* AMPHIDIPLOID

By Dontcho KOSTOFF

(Communicated by N. I. Vavilov, Member of the Academy, 25. I. 1937)

In centrifuging germinated seeds from various plants, we produced different types of chromosomal chimeras, including such with a complete chromosome duplication [Kostoff([3],[4]) 1935, and unpublished]. Rajably, one of our students, produced such chimeras in various plants and even a tetraploid *Matthiola*. We applied this method for inducing chromosome doubling in hybrid seedlings in order to produce fertile amphidiploid plants from sterile hybrids. We produced first a large amount of seeds in crossing *N. rustica* (a *texana* type) with *N. tabacum* var. *Basma*. The seeds were sown in filter paper. They germinated during a very long period of time. We used only those that germinated during the first 12 days. They were centrifuged when just started to germinate in series, each series being centrifuged several days, and then the seedlings were planted in pots (with soil+sand). When the seedlings grew about $1^1/_2$ cm high they were transplanted each in a pot.

Fig. 1. *K*—*N. rustica; L*—*N. tabacum; M*—hybrid F_1 (*N. rustica*×*N. tabacum*); *N*—Amphidiploid *N. rustica*×*N. tabacum*.

Normal *N. rustica* and *N. tabacum* hybrids are self sterile. If a chromosome doubling has occurred following centrifuging in a cell and a plant or a branch have developed from this cell, such a hybrid plant or branch, having a double chromosome number, should be fertile, or highly fertile being amphidiploid. We raised 81 centrifuged hybrids. One of them was chromosomal chimera, having sterile top and one fertile side branch. The fertile branch had a double chromosome number. During the first meiotic metaphase we counted 46, 47, 48, 49 and 50 chromatine bodies; most frequently, however, 48 were found. During the second metaphase we found usually metaphase plates with 48 chromosomes, though such with more than 48 as well as less than 48 chromosomes were also seen. In a few pollen mother cells the chromosome number in both second methaphase plates was possible to count. The chromosome number in both plates together was 96. Considering the fact that F_1 hybrids have 48 somatic chromosomes (24 *rustica*+24 *tabacum*), the fertile

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AGRO-PHYSIOLOGY

YAROVIZATION OF WHEAT HYBRIDS OF THE FIRST GENERATION

By E. S. SAPRYGINA

(Communicated by N. I. Vavilov, Member of the Academy, 5. I. 1937)

T. D. Lysenko ([1],[2]), on the basis of his work in the southern part of the USSR at Odessa, came to the conclusion that the development of hybrids of the first generation takes place by short stages and that the short stages of development are completely dominant over the long ones. Lysenko's work was the stimulus for our own investigations, which were undertaken because not all the details of this problem had been sufficiently worked out. In this present article we give a short description of part of our experimental data on the reaction of the first generation of wheat hybrids to yarovization—a question as yet not studied at all. We believe that our material will contribute to an understanding of the significance of the first generation on the selection of parent pairs when developing varieties having one or another vegetative period.

In 1930, in Saratov, M. I. Saltykovski ([3]) studied the infleunce of yarovization on hybrids of the first generation and drew the conclusion that yarovization hastens the development of certain first generation wheat hybrids. In the summer of 1936 at Bezenchuk Experimental Station we carried out experiments on a more extensive plan to study the infleunce of yarovization on wheat hybrids. In order to subject the plants experimented on to conditions more or less approximating various geographic regions, in our 1936 experiments we introduced, aside from yarovization, different day lengths and different temperature regimes. The plants experimented on were grown in the natural day, as it is at Bezenchuk, in a continuous day which was created by supplementary electric light switched on during the night hours, and in a variable day, i. e. a 10-hour day at the beginning of the development and then, 20 days after the wheat came up, continuous illumination.

Different temperature regimes were provided by sowing at three different dates: early sowing, April 26th; middle, May 8 th; and late, May 19th. The first sowing date coincided with early field sowings at Bezenchuk. Seed of parents and hybrids was yarovized at a temperature of 0 to+2° C. The sowing consisted of the three combinations (0321 × BG21; 48/02 × BG4 and 25183 × BG4) shown in Table 2; length of yarovization was, for the early sowing, 50 days, for the middle sowing, 62 days, for the late sowing, 73 days. For the other hybrids (Table 3) sown late, the period of yarovization was only 33 days. The seed was introduced into the soil by means of Stebutov apparatus. It was sown in rows, hybrids in between and parents alongside. Alto-

gether, there were 40 combinations in the different variants of the experiments. The parent pairs of these combinations were, on the one hand, spring wheats—Prelude (American), 0274 (Odessa), 0841 (Krasnokutsk), 0321 (Western Siberian), 48/02 (Saratov), 25183 (Afghanistan wheat) and 3483* (wheat from the world wide collection of the All-Union Institute of Plant Industry); on the other hand, winter wheats—329 (Saratov), BG21 and BG4 (Bezenchuk), Kooperatorka (Odessa) and 0534 (Azerdaijan). In the matter of developmental stages, winter wheats 0329, BG21 and BG4 are characterized by a long stage of yarovization and a short light stage. Kooperatorka has a long stage of yarovization; the light stage is also long, but considerably shorter than in the preceding varieties, 0534 has a long stage of yarovization, like Kooperatorka, but a short light stage. The spring wheats all have a short stage of yarovization, but differ much in the length of the light stage. Prelude and 25183 have short light stages; 0841, 48/02 and 0274 have light stages of medium length; in 3483 and 0321, it is long.

Owing to lack of space, we will not dwell on the details of the experiment, nor analyse the materials of all the combinations, but will cite only the data concerning the 14 combinations grown under conditions of a natural day length and a continuous illumination. All the other data confirm the conclusions that we draw from these 14 combinations.

Observations on the coming up, tillering and earing were made on each plant separately. The dates of earing are given in the tables for half or more of the plants. In the tables, the days of earing are denoted by Arabic numerals, the months by Roman ones. A dash indicates that the corresponding variant did not exist; plus (+) before figures indicates a delay and minus (—), a hastening of earing (Tables 2 and 3).

We will turn now to the data on the earing of plants grown in normal daylight. The data of the experiment (Table 1) plainly show that non-yarovized F_1-hybrids grown in natural light are, in most combinations of our experiments, tardy in earing as compared with their spring-wheat parents. The later the sowing data, that is, the higher the temperature at which the hybrids develop, the more protracted is the vegetative period of these hybrids as compared with the spring-wheat parent forms. (In the third ten-day period of April, the average temperature was 11.9° C.; during the 1st, 2nd and 3rd ten-day periods of May, it was, respectively, 11, 11.7 and 18. 4°; during June, 24.5, 22. 5 and 22.9, and during July, 22.1, 23.9 and 27. 1°. Thus, Prelude $\times$ 0534 F_1-hybrids, early sowing, eared 3 days, middle sowing, 9 days, and late sowing, 12 days later than their spring-wheat parents, while with 25183 $\times$ BG4 hybrids the earing was, for the early sowing, 10 days, for the middle, 13 days, and for the late sowing, 19 days later than in the spring-wheat parent, and for 3483 $\times$ 0534 hybrids it was 5, 12 and 20 days later respectively.

At the same time, it follows from the data of these experiments that yarovization of hybrids of the first generation hastens development (Table 2). Yarovized 0321 $\times$ BG21 hybrids grown under conditions of the normal day, eared, early sowing, 5 days, middle sowing, 14 days, and late sowing, 22 days earlier than non-yarovized hybrids. In the case of 25183 $\times$ BG4 hybrids, the hastening was 6, 13 and 19 days respectively. At the same time, the results of our experiments in every respect confirm the experimental data obtained by M. I. Saltykovski in 1930, showing that F_1-hybrid of spring-wheats with winter-wheats which are very slow in earing as compared with the

* This is the plot number in T. D. Lysenko's nursery in the Institute of Plant-Breeding and Genetics.

Table 1

The Development of Non-Yarovized Spring-Wheat Parent and F_1-Hybrid as Affected by Time of Sowing

Combinations and parent forms	Normal day						24-hour day					
	Earing dates of the various sowings			Lag in earing as compared with spring parent, in days			Earing dates of the various sowings			Lag in earing as compared with spring parent, in days		
	26/IV	8/V	19/V	26/IV	8/V	19/V	26/IV	8/V	19/V	26/IV	8/V	19/V
Prelude	10/VI	16/VI	22/VI	0	0	0	10/VI	14/VI	22/VI	0	0	0
Prelude × 0534	13/VI	25/VI	4/VII	3	9	12	13/VI	21/VI	30/VI	3	7	8
Prelude × Kooperatorka	16/VI	23/VI	29/VI	6	7	7	15/VI	19/VI	27/VI	5	5	5
Prelude × 0329	17/VI	26/VI	4/VII	7	10	12	15/VI	20/VI	2/VII	5	6	10
0274	19/VI	27/VI	6/VII	0	0	0	18/VI	24/VI	30/VI	0	0	0
0274 × 0534	19/VI	26/VI	4/VII	0	—1	—2	16/VI	22/VI	29/VI	—2	—2	—1
0274 × Kooperatorka	20/VI	28/VI	6/VII	1	1	0	19/VI	25/VI	30/VI	1	1	0
0841	14/VI	24/VI	1/VII	0	0	0	12/VI	20/VI	30/VI	0	0	0
0841 × Kooperatorka	19/VI	1/VII	9/VII	5	7	8	17/VI	26/VI	6/VII	5	6	6
0841 × 0329	19/VI	30/VI	13/VII	5	6	12	20/VI	28/VI	10/VII	8	8	10
0321	30/VI	10/VII	20/VII	0	0	0	26/VI	6/VII	15/VII	0	0	0
0321 × 0534	4/VII	14/VII	1/VIII	4	4	10	30/VI	10/VII	23/VII	4	4	8
0321 × Kooperatorka	30/VI	13/VII	27/VII	0	3	7	28/VI	11/VII	20/VII	2	5	5
3483	22/VI	3/VII	9/VII	0	0	0	19/VI	29/VI	7/VII	0	0	0
3483 × 0534	27/VI	15/VII	29/VII	5	12	20	21/VI	24/VI	15/VII	2	5	8
3483 × Kooperatorka	30/VI	20/VII	29/VII	8	17	20	14/VI	12/VII	22/VII	5	13	15
0321 × BG 21	29/VI	15/VII	26/VII	1	5	6	28/VI	10/VII	—	2	4	—
48/02	17/VI	25/VI	3/VII	0	0	0	16/VI	23/VI	1/VII	0	0	0
48/02 × BG4	21/VI	1/VII	10/VII	4	6	7	19/VI	27/VI	—	3	4	—
25183	9/VI	15/VI	26/VI	0	0	0	9/VI	15/VI	26/VI	0	0	0
25183 × BG4	19/VI	28/VI	15/VII	10	13	19	17/VI	27/VI	—	8	12	—

Table 2

The Hastening of Development of Yarovized F_1-Hybrids as Affected by Time of Sowing

Parent forms and combinations	Normal day									24-hour day								
	Earing dates of the various sowings			Hastening of development of F_1 as compared with spring parent, in days			Hastening of development of F_1 due to yarovization, in days			Earing dates of the various sowings			Hastening of development of F_1 as compared with spring parent in days			Hastening of development of F_1 due to yarovization, in days		
	26/IV	8/V	19/V	26/IV	8/V	19/V	26/IV	8/V	19/V	26/IV	8/V	19/V	26/IV	8/V	19/V	26/IV	8/V	19/V
0321, non-yarovized	30/VI	10/VII	20/VII	0	0	0	—	—	—	26/VI	6/VII	15/VII	0	0	0	—	—	—
0321 × BG21, non-yarovized	29/VI	15/VII	26/VII	— 1	+ 5	+ 6	0	0	0	28/VI	10/VII	—	+ 2	+ 4	—	0	0	0
0321 × BG21, yarovized	24/VI	1/VII	4/VII	— 6	— 9	—16	—5	—14	—22	18/VI	23/VI	1/VII	— 8	—13	—14	—10	—13	—
BG21, yarovized	1/VII	3/VII	8/VII	+ 1	— 7	—12	—	—	—	21/VI	29/VI	3/VII	— 5	— 7	—12	—	—	—
48/02, non-yarovized	17/VI	25/VI	3/VII	0	0	0	—	—	—	16/VI	23/VI	1/VII	0	0	0	—	—	—
48/02 × BG4, non-yarovized	21/VI	1/VII	10/VII	+ 4	+ 6	+ 7	0	0	0	19/VI	27/VI	—	+ 3	+ 4	—	0	0	0
48/02 × BG4, yarovized	17/VI	25/VI	3/VII	0	0	0	—4	— 6	— 7	16/VI	23/VI	30/VI	0	0	— 1	— 3	— 4	—
BG4, yarovized	4/VII		8/VII	+17	+14	+ 5	—	—	—	4/VII	4/VII	6/VII	+18	+11	+ 5	—	—	—
25183, non-yarovized	9/VI	9/VII 15/VI	26/VI	0	0	0	—	—	—	9/VI	15/VI	26/VI	0	0	0	—	—	—
25183 × BG4, non-yarovized	19/VI	28/VI	15/VII	+10	+13	+19	0	0	0	17/VI	27/VI	—	+ 8	+12	—	0	0	0
25183 × BG4, yarovized	13/VI	15/VI	26/VI	+ 4	0	0	—6	—13	—19	13/VI	16/VI	26/VI	+ 4	+ 1	0	— 4	—11	—

Table 3

Earing Dates of F_1-Hybrids and Parents Sown on May 19, 1936

Combinations	Normal day					24-hour day				
	Spring parent, non-yarovized ♀	F_1		Winter parent yarovized 70 days ♂	Hastening of earing of F_1 due to yarovization as compared, with non-yarovized F_1, in days	Spring parent, non-yarovized ♀	F_1		Winter parent, yarovized 70 days ♂	Hastening of earing of F_1 due to yaro. vization as compared with non-yarovized F_1 in days
		non-yarovized	yarovized 33 days				non-yarovized	yarovized 33 days		
Prelude × 0534	22/VI	4/VII	23/VI	—	11	22/VI	30/VI	23/VI	—	7
Prelude × Kooperatorka	22/VI	29/VI	21/VI	5/VII	8	22/VI	27/VI	20/VI	2/VII	7
Prelude × 0329	22/VI	4/VII	29/VI	14/VII	5	22/VI	2/VII	27/VI	12/VII	5
0274 × 0534	6/VII	4/VII	4/VII	—	0	30/VI	29/VI	29/VI	—	0
0274 × Kooperatorka	6/VII	6/VII	4/VII	5/VII	2	30/VI	30/VI	30/VI	2/VII	0
0841 × Kooperatorka	1/VII	9/VII	2/VII	5/VII	7	30/VI	6/VII	30/VI	2/VII	6
0841 × 0329	1/VII	13/VII	1/VII	14/VII	12	30/VII	10/VII	30/VI	12/VII	10
0321 × 0534	20/VII	1/VIII	14/VII	—	18	15/VII	23/VII	10/VII	—	13
0321 × Kooperatorka	20/VII	27/VII	20/VII	5/VII	7	15/VII	20/VII	15/VII	2/VII	5
3483 × 0534	9/VII	29/VII	8/VII	—	21	7/VII	15/VII	—	—	—

spring-wheat parent, ear, after yarovization, simultaneously with, or earlier than, the early-ripening parent. 0321×BG21 F_1-hybrids, when sowing late, were six days slower in development than the spring-wheat parent if non-yarovised seed was sown, but with yarovized seed they were 16 days earlier than the spring-wheat parent (Table 2, normal day).

The same rule is to be seen holding true for the rest of the hybrids of the first generation included in the experiment. In Table 3 are shown the data for ten combinations, late sowing, of yarovized and non-yarovized seed. The hastening of earing in the case of yarovized hybrids grown in the natural day length, varies from 5 to 21 days, as compared with non-yarovized hybrids. Just as in the four preceding crosses, in these ten combinations, F_1-hybrids that had retarded in earing, as compared with their spring-wheat parent, eared, after yarovization, either earlier than, or simultaneously with, the early-ripening parent. Hybrids 0274×0534 and 0274×Kooperatorka are exceptions. Non-yarovized F_1-hybrids of these combinations ear simultaneously with, or earlier than, the early-ripening parent and their development is not hastened by yarovization. The Institute of Plant Breeding and Genetics worked with 0274×0534 hybrids, and our data with respect to this combination fully coincide with theirs.

In the majority of F_1-hybrids grown under supplementary electric light, i. e. under the «24-hour day», so called by us, a delay in development in comparison with the spring-wheat parent is also observed, but this delay is somewhat less than in the case of hybrids grown in the natural day (Table 1, right column). The effect of yarovization on hybrids of the first generation grown under continuous illumination is also somewhat less than on hybrids grown in the natural day (Table 3, right column).

Conclusions

1. Earliness of ripening depends, in hybrids of the first generation, on conditions of growth. One or another stage may become dominant as a result of external conditions. In some conditions, the development proceeds by short stages that is, the short stages dominate over the long; under other conditions, earliness of ripening takes on a plainly intermediate character.

2. In late sowings, when the development of the hybrids takes place at higher temperatures, the delay in the earing of hybrids resulting from crossing winter wheats with spring wheats greatly increases and, in a number of combinations, plainly takes on the character of intermediate inheritance. Hence, in regions with a long cold spring, such as is usual in the south, a considerable number of the hybrids resulting from crossings of spring wheats with winter wheats and, especially, from crossings with semi-winter wheats, ear, when sown early, either simultaneously with, or earlier than, the spring-wheat parent. On the contrary, in regions, or in years, distinguished by a short warm spring, such as is common in the south-eastern part of the USSR, where warm or hot weather frequently sets in immediately after sowing, many of the hybrids, when sown with non-yarovized seed, will ear later than the more early-ripening parent, as is likewise the case for summer sowings in all regions.

Bezenchuk Regional Experimental Station of Agriculture.

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PLANT PHYSIOLOGY

ON THE TRUE INFLUENCE OF BACTERIORHIZAL MICROORGANISMS ON THE GERMINATION OF SEEDS. II

By A. A. ISAKOVA

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In a previous paper* we set forth the results of our work on the germination of seeds when affected by bacteriorhizal microorganisms.

That work emphasized the powerful stimulation of seed germination produced by the treatment of such seeds, previous to sowing, with various suspensions of bacteriorhizal microbe complexes. Our subsequent problem was to ascertain what was the ultimate carrier of the affecting factor, whether the bacterial cell or the substances produced by it and accumulated in the medium.

In the solution of this problem, we used, on the one hand, an intact bacterial complex, and, on the other, the filtrates obtained by the filtration of such complexes through Chamberland L-3 candles. Experiments were made with various plants, viz., cotton seeds, oats, wheat, etc.

The first experiment was made with cotton seeds on baked sand (Table 1). The maceration lasted 19 hours at 16°, the experiment being made at 24°. The germination lasted 2 days.

Table 1

	Percentage of germinating seeds	Percentage on control	Plus „ minus
Control (tap water)	14.0	100.0	
Bacteriorhiza of cotton	42.0	300.0	+200.0
Filtrate of above	32.0	229.0	+129.0
Bacteriorhiza of tobacco	6.0	42.0	− 67.2
Filtrate of above	70.0	571.0	+471.0
Bacteriorhiza of wheat	18.0	128.5	+ 28.5
Filtrate of above	16.0	114.2	+ 14.2
Bacteriorhiza of oats	8.0	57.1	−429
Filtrate of above	70.0	571.0	+471.0
Bacteriorhiza of hemp	28.0	200	+100.0
Filtrate of above	50.0	357	+257.0
Soil mixture	44.0	314	+214.0
Filtrate of above	90.0	642	+542.0

* C. R. Acad. Sci URSS, IV, 9 (1936).

This experiment shows that in baked sand, where bacteria are practically absent, the filtration of bacteriorhizal microbe complexes enhances considerably their action on the seeds. A sharp acceleration of the germination process was caused by the filtrates of such bacteriorhizas which exercise an undoubtedly depressing influence on germination, i. e. those of tobacco and oats. In this case, filtration fully removes the depressing factor; to a smaller extent this may be said of bacteriorhiza which stimulate germination, as, in these cases, an acceleration of germination also takes place, but its increase is not so great.

We deemed it necessary to test the results obtained by using a medium enriched by a microbe complex in natural soil.

A repetition of the experiment with cotton seeds in natural soil conditions gave the following results (Table 2).

Table 2

	Percentage of germination	Percentage on control	Plus minus
Control (tap water)	20	100	
Bacteriorhiza of cotton seed	52	260	+160
Filtrate of above	60	300	+200
Boiled bacteriorhiza of cotton seed	42	210	+110
Bacteriorhiza of tobacco	10	50	— 50
Fiftrate of above	10	50	— 50
Boiled bacteriorhiza of tobacco	12	60	— 40
Bacteriorhiza of castor-oil plant	34	170	+ 70
Filtrate of above	42	210	+110
Boiled bacteriorhiza of castor-oil plant	28	140	+ 40
Bacteriorhiza of wheat	24	120	+ 20
Filtrate of above	32	160	+ 60
Boiled bacteriorhiza of wheat	32	160	+ 60
Bacteriorhiza of oats	14	70	— 30
Filtrate of above	24	120	+ 20
Boiled bacteriorhiza of oats	10	50	— 50
Soil mixture	28	140	+ 40
Filtrate of above	30	150	+ 50
Boiled soil mixture	16	80	— 20

In natural soil, the presence of the whole soil complex resulted in a marked smoothing down of the differences observable in the experiment made on baked sand, the process being, however, substantially the same. The nature of the influence exercised by the various bacteriorhizas remained unchanged. Both tobacco and oats gave in either case a sharply marked retardation of germination. The filtration, which had given a striking effect for these cultures when used in sand yielded less striking results, but some stimulation of germination as compared with bacteriorhiza was noticeable in every instance.

The behaviour of the soil mixture was similar to that of the soil complex used as control, which is easily accounted for, since the action was in this case exerted by the same microflora as is contained in the soil complex.

The boiling of bacteriorhiza reduces its effect on the seeds. This effect, however, is in nearly all cases a higher one than in control experiments.

The stimulating effect of the bacteriorhizas, which had accelerated germination, continued to affect the further development of the plants. The experiments with wheat in natural soil conditions gave similar results. A maximum

acceleration of germination was obtained in using the bacteriorhizas of wheat, and the filtrate of the bacteriorhiza of wheat. A considerable effect was obtained by boiling the bacteriorhiza of cotton and oats.

The culture of oats does not yield such results; after a 19-hour action of the medium, the best effect was obtained, in practically all instances, with boiled bacteriorhizas. The greatest accelerations of germination were obtained with boiled bacteriorhizas of castor-oil seed, cotton and tobacco, the difference from the control plants being as high as 66—73%. Some acceleration of the process of germination was recorded for the bacteriorhizas of tobacco (58%), wheat (54%), and the filtrates of oats (54.1%) and castor-oil seed (65.6%).

The difference in the behaviour of the oats culture may be put down to the presence of a stout integument and also to the peculiarities of germination, since the roots are the first to appear, while the shoots do not sprout until later.

In view of the results obtained by the above experiments, we have arrived at the following conclusions:

1) Cultivated plants, when treated with bacteriorhiza, display individual peculiarities in their behaviour, e. g., while cotton seeds and wheat are affected most by their own bacteriorhizas, oats showed but a poor reaction when treated with its own bacteriorhizas.

2) The bacterial complex selected by the root system of a plant affects the latter through the metabolism products discharged by its cells into the surrounding medium. This is proved by the increase of the effect if filtrates are used and by the removal of the principle retarding germination in certain bacteriorhizas.

3) While boiling lowers the effect in the case of some plants, it enhances that effect in some others (e. g. oats).

This may be due to the destruction of some unstable metabolism products which may affect some plants to a greater extent than they affect others.

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ZOOLOGIE

EINE NEUE EKTOPARASITISCHE MOLLUSKE DER GATTUNG *MEGADENUS* ROSÈN

Von A. V. IVANOV

(Vorgelegt von S. A. Zernov, Mitglied der Akademie, d. 9. I. 1937)

Bei der Durchsicht der von M. N. Krivobok*, Mitarbeiter des Pazifischen Fischerei-Instituts, im Gelben Meer (Trawler «Blücher») erbeuteten Stachelhäuter entdeckte ich an zwei Seesternexemplaren ektoparasitische Mollusken, die sich als neue Art der Gattung *Megadenus Rosèn* (Fam. *Stiliferidae*) erwiesen. Die mit dieser Molluske infizierten Seesterne gehören zur Art *Anthenoides rugulosus* Fischer, die von den Philippinischen Inseln her bekannt ist.

Bemerkenswert ist, dass die hier beschriebene Molluske schon früher erbeutet wurde. So sind in W. K. Fischers Monographie, in der *Anthenoides rugulosus* beschrieben wird, auf der Photographie dieses Seesternes deutlich mehrere ektoparasitische Gastropoden zu sehen, in denen unsere Form leicht erkannt werden kann (1). Im Text werden diese Tiere aber nirgends erwähnt und sind somit unerforscht geblieben.

An beiden Exemplaren von *Anthenoides rugulosus* fand ich im Ganzen 6 Mollusken. Die Parasiten befinden sich an der Dorsalseite des Wirtes in kelchartigen, oben mehr oder weniger offenen Vertiefungen des Integuments (Fig. 1)

Die den Parasiten umgebenden Kalkplatten der Integumente des Wirtes sind gewöhnlich verdickt und mehr oder weniger unregelmässig deformiert. Der Boden des vom Parasiten eingenommenen Hohlraumes wird von stark verdickten aneinanderliegenden Kalkplatten gebildet. Stellenweise sind sie in zwei Reihen angeordnet und bilden gegen die Leibeshöhle des Wirtes eine Art unregelmässiger gallenartiger Anschwellung oder Beule (Fig. 1, *pl'*). Zweifellos ist die Bildung dieser Platten eine Schutzreaktion des Wirtes auf die Reizung seitens des Parasiten.

Unsere Molluske hat, im Gegensatz zu allen bekannten Stiliferiden, gar keinen Rüssel. Der Parasit ist also von der Leibeshöhle des Wirtes vollständig isoliert (Fig. 1.). Der Scheinmantel ist gut ausgebildet. Er geht vom Vorderrand des Kopfes aus hat das Aussehen einer grossen aufwärts auf die Schale gebogenen Hautfalte. Oben ist der Scheinmantel weit offen. Seine grösste Entfaltung erreicht er rechts, wo er die Schalenspitze etwas überragt, die kleinste—links, wo er nur einen Teil der letzten Schalenwindung bedeckt

* Ich spreche hiermit M. N. Krivobok für das liebenswürdig überlassene Material, sowie Dr. A. M. Djakonov für die Bestimmung der Seesterne meinen Dank aus.

(Fig. 1 und 2, *sm*). Dieser Umstand erklärt sich aus der Orientierung der Mollusken am Wirtskörper. Die Schale liegt stets so, dass ihre Spitze sich an den Rand des von der Molluske eingenommenen Hohlraums legt. Dabei ist die linke Oberfläche fast sämtlicher Schalenwindungen von oben sichtbar (Fig. 1, *sch*). Die Befestigung am Wirtskörper geschieht vermittels des Scheinmantels. Die Integumente des Wirtes sind an den Rändern des Hohlraumes stark verflacht, ausgezogen und hängen als weiter Trichter zwischen der Schale und dem Scheinmantel in den Hohlraum hinein, und legen sich dabei an die Innenfläche des Scheinmantels. Die verdickte Basis des Trichters enthält ausser Bindegewebe kleine unregelmässige Kalkplättchen (Fig, 1. *tr*). Auf

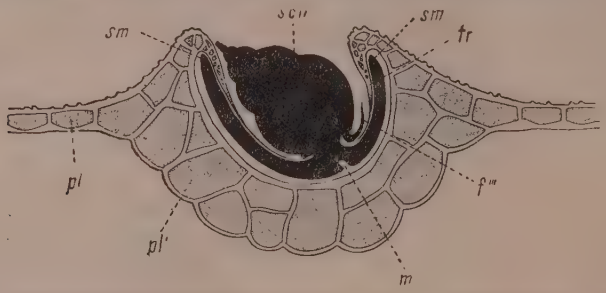

Fig. 1. Die Lage des *Megadenus arrhynchus* am Körper von *Anthenoides rugulosus*. Schema. *f'''*—gefurchte Pedalfalte: *m*—Mundöffnung: *pl* und *pl'*—Platten des Integuments des Wirtes: *sch*—Schale: *sm*—Scheinmantel: *tr*—der vom Integument des Wirtes gebildete Trichter.

diese Weise hält der in den schmalen Raum zwischen Höhlenwandung und Trichter eindringende Scheinmantel den Parasiten unbeweglich.

Die rechtsgewundene Schale ist kurz kegelförmig, fast eiförmig und besteht aus $6^1/_2$—7 Windungen. Die ersten drei Windungen bilden einen gut ausgeprägten Apex (mucro). Die nachfolgenden Windungen sind gleichmässig gewölbt und aufgetrieben, besonders die letzte. Der Apex ist höher als die 4. Windung. Jede nachfolgende Windung ist mehr als doppelt so hoch wie die vorhergehende. Die Schale ist porzellanartig weiss, der Apex glashell, die Schalenoberfläche ganz glatt, glänzend, mit kaum wahrnehmbaren Wachstumslinien. Alle Nähte sind deutlich mit einer hellen Linie gesäumt. Die Schalenwände sind ziemlich dick und undurchsichtig. Die Mündung ist breit, unregelmässig halbmondförmig, mit merklichem oberem Winkel und mehr oder weniger geradem Kolumellarrand. Der scharfe Aussenrand hat kreisförmigen Umriss (Fig. 2, *sch*). Die Höhe der Schale bei einem der grösseren Exemplare beträgt 6.4 mm mist 5.9 mm grösster Breite. Die Höhe des Apex dieses Exemplars beträgt 0.4 mm.

Der Kopf ist schwach abgesondert. An der Basis des Scheinmantels und noch darüber liegt ein Paar ziemlich grosser Fühler (Fig. 3, *t*). Augen äusserlich nicht wahrnehmbar; sie sind stark reduziert und liegen tief unter dem Integument im Bindegewebe. Die Mundöffnung liegt am vorderen Körperende unmittelbar an der Basis des Scheinmantels (Fig. 1.3, *m*). Fuss stark reduziert, modifiziert und naturgemäss ohne lokomotorische Funktion. Er ist nach rechts verschoben, liegt mit dem Vorderrande dem rechten Kopfühler an, und besteht aus zwei kompakten, durch eine Rinne getrennten Teilen (Fig. 3, *f'* und *f''*). Hinten grenzt eine verflachte, rinnenförmige muskulöse Falte an diese Fussteile. Sie umgürtelt die Basis des Visceralsacks von hinten und links, wobei sie bis zu dem linken Kopffühler und dem Eingang in die Mantelhöhle

reicht (Fig. 3 *f'''*). Die Innervation zeigt, dass dieses Gebilde ein umgebildeter Teil des Fusses ist. Operculum fehlt. Die Schleim absondernde Randdrüse ist vorhanden. Sie ist ungewöhnlich stark entwickelt, dringt tief in die Gewebe des Körpers ein, bei manchen Exemplaren sogar bis zum Visceralganglion reichend. Ihre Öffnung liegt rechts am ersten Fussabschnitt. Auch die Fussolendrüse ist wohlentwickelt. Sie mündet auf dem Grunde der Furche zwischen dem ersten und zweiten Fussabschnitt. Mantel normal ausgebildet. In der Mantelhöhle liegt eine grosse Kieme und eine Hypobranchialdrüse.

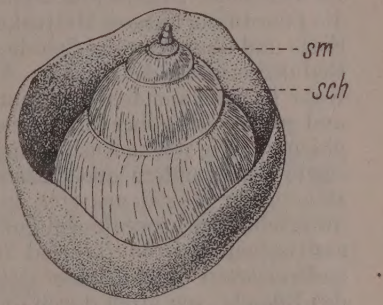

Fig. 2. *Megadenus arrhynchus*. Äussere Ansicht; *sch*—Schale; *sm*—Scheinmantel.

Die innere Organisation unterscheidet sich fast gar nich von der Organisation freilebender Gastropoden, und nähert sich in den Einzelheiten der Organisation von *Megadenus holothuricola* Rosèn(2) und *Meg. voeltzkowi* Schepman et Nierstrasz (3). Das Verdauungssystem besteht aus einem muskulösen Pharynx, Oesophagus, Leber, Dünndarm und Enddarm. Die Analöffnung liegt in der Tiefe der Mantelhöhle. Radula, Kiefer, Speicheldrüsen und möglicherweise auch Magen fehlen. Einzelne Leberlappen und Gonadenlappen nehmen, durcheinander gemischt, den grössten Teil des Visceralsacks ein. Zirkulationssystem normal entwickelt. Herz links gelegen und vom Pericardialraum umgeben, bestehend aus Vorhof und Kammer. Das Zentralnervensystem ist im Kopfabschnitt vom blutgefüllten Kopfsinus umgeben. Niere gut ausgebildet, mit zahlreichen Trabekeln versehen.

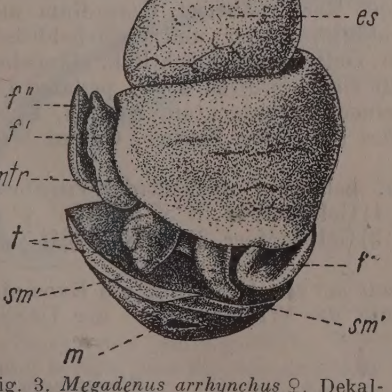

Fig. 3. *Megadenus arrhynchus* ♀. Dekalziniertes Tier mit entferntem Scheinmantel; *es*—Eingeweidesack: *f'*, *f''* und *f'''*—Fuss: *m*—Mundöffnung: *mr*—Mantelrand: *sm*—Spuren des entfernten Scheinmantels: *t*—Fühler.

Cerebral- Pedal- und Pleuralganglien stark genähert Ein Paar Buccalganglien, Supra- und Subintestinalganglion und ein Visceralganglion vorhanden. Chiastoneurie deutlich. Neben den Pedalganglien liegt ein Paar Otocysten. Getrenntgeschlechtlich die Männchen sind viel kleiner als die Weibchen, offenbar stäts in der Nähe derselben festsitzend und die gleiche Lebensweise führend. Die Organisation der Männchen unterscheidet sich nicht von der Organisation der Weibchen, mit Ausnahme des Genitalsystems. Das weibliche Geschlechtssystem besteht aus einem stark gegliederten lappigen Ovarium und einem Ausgang. Ein Teil des letzteren ist in einem sehr umfangreichen, hauptsächlich Schleim absondernden Uterus differenziert. Receptaculum seminis vorhanden. Das männliche Genitalsystem setzt sich aus einem lappigen Hoden, einem breiten Samenleiter und einem sehr grossen gefurchten Penis pedaler Herkunft zusammen.

Unsere Form gehört also zweifellos zur Familie des *Stiliferidae* (Gruppe *Aglossa*), obgleich sie von allen Gattungen dieser Familie durch das völlige Fehlen eines Rüssels abweicht. Letzterem Umstand darf jedoch keine besonders grosse Bedeutung beigemessen werden, da es bekannt ist, wie sehr die Art und der Grad der Rüsseldifferenzierung von den Existenzverhältnissen verschiedener *Stiliferidae* abhängt. Eine Reihe von Merkmalen rechtfertigt die Zuordnung unseres Mollusken zur Gattung *Megadenus*—nämlich folgende: Form und Charakter der Schale, Reduktion des Fusses, Fehlen des Operculums, Reduktionsgrad der Augen, Vorhandensein eines wohlentwickelten, vom Kopf herstammenden Scheinmantels, Vorhandensein einer normalen Kieme und grossen Hypobranchialdrüse, getrennte Geschlechter und Sexualdimorphismus. Die starke Ausbildung der Pedaldrüsen, insbesondere der Randdrüse, sowie einige andere anatomische Besonderheiten weisen ebenfalls auf nahe Beziehung zu Megadenusarten hin. Alle diese Merkmale in ihrer Gesamtheit unterscheiden unsere Form gut von den mit *Megadenus* verwandten ektoparasitischen *Mucronalia*- und *Stilifer*-Arten. Von den bisher bekannten Megadenusarten unterscheidet sich die beschriebene Art, ausser durch das Fehlen des Rüssels, vor allen durch ungleichmässige Ausbildung des Scheinmantels, charakteristische Eigentümlichkeiten des Fussbaues, eigenartige Befestigung am Wirte, sowie durch einige Merkmale der inneren Organisation. Konchiologisch steht sie *Megadenus voeltzkowi* Schepman et Nierstrasz [3] am nächsten.

Eine merkwürdige Eigentümlichkeit der neuen Art ist das Fehlen eines Rüssels und die damit zusammenhängende Art des Parasitismus. Im Hinblick darauf gebe ich der neuen Art den Namen *Megadenus arrhynchus*, sp. n.

Diagnose der Art

Schale mit den Merkmalen der Gattung *Megadenus* Rosèn. Rüssel fehlt. Scheinmantel wohlentwickelt. Fuss merklich reduziert und zum Teil in eine sichelförmige gefurchte Falte ausgezogen. Operculum fehlt. Beide Pedaldrüsen stark entwickelt. Fühler normal Augen stark reduziert. Ktenidium und Hypobranchialdrüse gut ausgebildet. Radula, Kiefer und Speicheldrüsen fehlen. Dünndarm und Enddarm verkürzt. Getrenntgeschlechtlich. Männchen fünfmal so klein wie das Weibchen, mit einem grossen Penis pedalen Ursprungs. Weibliches Genitalsystem mit einem Receptaculum seminis. Ektoparasiten an den Seesternen *Anthenoides rugulosus* Fischer. Gelbes Meer und wahrscheinlich auch Philippine.

Mit *Megadenus arrhynchus* sp. n. befallene *Anthenoides rugulosus* wurden an folgenden Stellen erbeutet: 1) Gelbes Meer, 31°55′N—128° 0′ E, Tiefe 153—162 m, Sand, 21. II. 1931; 2) Gelbes Meer, 31°42′N—128°1 3′ E, Tiefe 171—175 m, Sand, 21. II. 1931.

Von den 6 Exemplaren des *Megadenus arrhynchus* wurde ein Exemplar dem Zoologischen Institut der Akademie der Wissenschaften der UdSSR übergeben.

Laboratorium für Zoologie
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Eingegangen
d.9.I.1937

ZITIERTE LITERATUR

[1] W. K. Fischer, Smiths Inst. U. S. Nat. Mus. Bull. 100, 338, Pl. 35, fig. 4 (1919). [2] N. Rosèn, Acta Univ. Lund. Nova Series, **6** (1910). [3] M. Schepman und N. Nierstrasz, Voeltzkows Reise in Ostafr., **4** (1931).

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EXPERIMENTELLE ZOOLOGIE

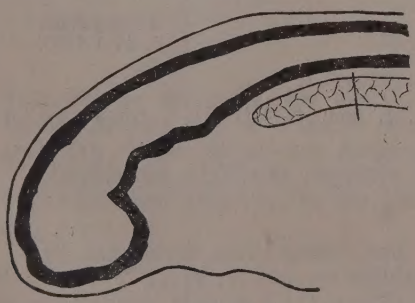
INDUKTION DES INFUNDIBULUMS DURCH DAS VORDERENDE DER CHORDA

Von T. A. BEDNJAKOVA

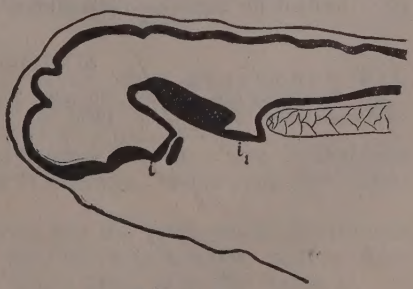
(*Vorgelegt von N. V. Nasonov, Mitglied der Akademie, d. 14. I. 1937*)

Zur Prüfung der von Filatow (1) im Jahre 1916 ausgesprochenen Annahme über die Möglichkeit eines Einflusses des Vorderendes des Chorda auf die Lage der Knorpelanlagen der Trabekeln und der Parachordalien veranstaltete ich einen Versuch, in dem das Vorderende der Chorda bei den sich auf dem Schwanzknospenstadium befindenden Axolotl-Embryonen entfernt wurde.

Beschreibung der Operation: der Schnitt wurde vom Pronephros bis zum Vorderende des Kiemenhügels auf dem Niveau des Unterrandes des



Schema 1.



Schema 2.

Nervensystems durchgeführt. Durch die auseinandergerückten Schnittränder konnte man die sich zu dieser Zeit völlig abgesonderte Chorda erkennen und ihr Ende ungefähr bis zum ersten Somiten entfernen.

Schema 1 stellt das Verhältnis zwischen Nervensystem und Chorda zurzeit der Operation dar und zeigt, dass die Anlage des Gehirntrichters (infundibulum) hier noch fehlt.

Die Schnitte durch 5—6 Tage nach der Operation fixierte Embryonen gaben nicht völlig bestimmte Angaben über den Einfluss des Vorderendes der Chorda auf die Lage der Knorpelanlagen, aus welchem Grunde über diesen Teil der Operationsergebnisse in der gegebenen Arbeit nicht mitgeteilt wird; festgestellt wurde aber ein völlig offensichtlicher Einfluss des Vorderendes des Chorda auf die Bildung des Infundibulums.

Auf Sagittalschnitten von mehreren Embryonen konnte konstatiert werden, dass neben dem auf gewöhnlicher Stelle (aus der Wand des Vorderhirns) entstandenen Trichter noch ein neuer beim neuen Vorderende der Chorda liegender Trichter aufgetreten war. Dieser zweite Trichter war aus dem Boden des Nachhirns gebildet (s. Schema 2).

Die Versuchsergebnisse können so gedeutet werden, dass das Vorderende der Chorda die Bildung eines Infundibulums aus dem Teil des Gehirns induziert, unter dem es sich befindet.

Die Bildung des Infundibulums aus alter Stelle kann vorläufig in zweifacher Weise erklärt werden: entweder dadurch, dass es zum Moment der Operation schon durch das Vorderende der Chorda determiniert war, oder dadurch, dass auf normaler Stelle seine Entwicklung ausser der Chorda auch noch von anderen Faktoren bedingt wird. In dieser Frage werden Operationen auf früheren Stadien grössere Klarheit schaffen.

In seinem Aufsatz über die Wechselwirkung des Keimblätter schreibt Mangold(2), indem er die Resultate der Entfernung des Chordamaterials bei der Tritonneurula anführt:

«Jetzt kann schon gesagt werden, dass das Infundibulum, das normalweise direkt an der Chordaspitze liegt, sich auch ausbildet, wenn die Chorda erst weiter hinten beginnt».

Dieser einzige Satz in Mangolds Aufsatz über die hier in Rede stehende Frage weist augenscheinlich nur darauf hin, dass das Infundibulum immerhin gebildet wird, falls das Vorderende der Chorda auch nach hinten versetzt ist. Hier wird von einem Trichter gesprochen, doch ist im Zitat leider nicht angegeben, ob er nach der Operation auf der neuen oder alten Stelle entsteht.

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Eingegangen
d. 14 I 1937.

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[1] Филатов, Русск. зоолог. журн., I, вып. 1—2 (1917). [2] Mangold, Naturwissenschaften, H. 48 (1936)